MACHINERY is registered as a newspaper at the General Post Office and the name is a registered trade mark

Published every Friday by
The Machinery Publishing Co., Ltd.
Copyright reserved
Price 1/3

•

LESLIE R. MASON
Managing Director
CHARLES H. BURDER
Editor

•

EDITORIAL OFFICE

REGISTERED OFFICE, SMALL AND CLASSIFIED ADVERTISEMENTS DEPARTMENT AND ENQUIRY BUREAU

CLIFTON HOUSE
83-117 EUSTON ROAD
LONDON, N.W.1.

Telephone: Euston 8441/2
Telegrams: Machtool, Norwest, London

•

HEAD OFFICE

SUBSCRIPTION, ADVERTISEMENT, SERVICE, PHOTOGRAPHIC, ACCOUNTS AND BOOK DEPARTMENTS

NATIONAL HOUSE
21 WEST STREET
BRIGHTON, 1

Telephone:
Brighton 27356
(3 lines)

Telegrams:
Machteel,
Brighton

NEW YORK:
93, Worth Street

PARIS:
15, Rue Bleue

•

CONTRIBUTIONS:—If you know of a more efficient way of designing a tool, gauge, fixture, or mechanism, machining, or forming a metal component, heat treating, plating or enamelling, handling parts or material, building up an assembly, or utilizing supplies, send it to the Editor.
Short comments upon published articles and letters on subjects concerning the metal working industries are particularly welcome. Payment will be made for exclusive articles.

SUBSCRIPTIONS:—Inland and overseas, 52 shillings per annum, post free. Cheques and Money Orders should be made payable to the Machinery Publishing Co., Ltd.

ADVERTISEMENTS:—Copy for displayed advertisements, if proofs are required, should reach the Brighton office 21 days in advance of publication. Rates on request.
Small (classified) advertisements can be accepted, space permitting, at the London office up to Saturday morning for publication on the following Friday: For rates, see p. 155.
Blocks are held at advertisers' own risk; no responsibility for loss is accepted by the publishers.

MANUSCRIPTS FOR BOOKS covering all branches of engineering production will receive careful consideration and should be sent to the Manager, Book Dept., MACHINERY, National House, 21 West St., Brighton, 1.

MACHINERY

A JOURNAL OF METAL-WORKING PRACTICE AND MACHINE TOOLS

Vol. 92, No. 2356 January 10, 1958

COPIES PRINTED.....11,500 per week

CERTIFIED DISTRIBUTION.....11,376 per week

CERTIFIED PAID DISTRIBUTION.....10,566 per week

CONTENTS

Editorial

PAGE

The Steel Supply Position 59

Principal Articles (*For Abstracts see next page*)

The Production of Components for Lambretta Motor Scooters 60
A New Spark-machining Technique 74
Skinner Unit Heads for Transfer Machines 77
Equipment for Automatically Coating Washing Machine Tubs with Slip 79
Nickols Automatic Sequence-control Equipment 87
Aircraft Manufactuing Practice—A Review of the British Industry 97
New Bar Rolling Mill at the Works of Sanderson Bros. & Newbould, Ltd..... 107

Short Articles

Carbide Form-tool Inserts Ground in Gangs 73
Morey Vertical Profiling and Milling Machine 76
Low Temperature Refrigeration Unit 96
New Showrooms for Elgar Machine Tool Co., Ltd. 109

New Production Equipment

Stanley 12½-in. Centre Sliding-bed Lathe 81
Moon Trimming and Beading Machine 81
New Brauer Toggle Clamps 82
Hy-Flex Double-column Hydraulic Milling Machine 83
Londex Pressure Switches 84
Hamilton Triple-action Press for Motor Car Body Stampings 84
Expert Transfer Machine for Operations on Motor Car Steering Columns 85
New Baldwin Manifold Valves 85
Whades Miniveyor Truck 86

News of the Industry

Manchester and District 111
Classified Advertisements 155
Index to Advertisers 193

CONDITIONS OF SALE AND SUPPLY.—MACHINERY is sold subject to the following conditions:
That it shall not, without the written consent of the publishers first given, be lent, resold, hired out or otherwise disposed of by way of trade except at the full retail price of 1s. 3d. and, that it shall not be lent, resold, hired out or otherwise disposed of in a mutilated condition or in any unauthorized cover by way of trade; or affixed to or as part of any publication or advertising literary or pictorial matter whatsoever.

Abstracts of Principal Articles

The Production of Components for Lambretta Motor Scooters.....P. 60

Following a brief description of the factory at Lambrate, Milan, Italy, in which the Innocenti company is now established, this first article of a series gives some details of the design of the current Lambretta scooter and its 150-c.c. engine. Manufacturing methods for pistons of two sizes, for 125- and 150-c.c. engines, are then described. The gravity die cast pistons are first heat-treated to promote dimensional stability, and various rough-turning, boring, and facing operations are then carried out on a Cimat machine. A total of seven holes is then drilled in various positions on a special Innocenti-built machine with unit heads, which are arranged about an indexing table. After this stage, the outside and end are semi-finish turned, and the ring grooves are rough-formed and finished on another Cimat machine. A third machine of this make is employed for cutting the circlip grooves, and finishing the gudgeon pin bores with single-point diamond tools. After the skirt register has been bored, and the end has been chamfered, three small brass pins are inserted in the piston ring grooves of each piston, with the aid of a special air-operated unit. Combined taper and oval grinding of the outside surface of the piston is then carried out on a Fortuna-Werke machine, on which the work-head is controlled by a cam. Tin plating follows, before the pistons are inspected and graded. (MACHINERY, 92—10/1/58.)

A New Spark-machining Technique...P. 74

At the works of the Lockheed Aircraft Corporation, U.S.A., spark-machining is extensively employed for finishing the cavities of impact extrusion dies. Special equipment has been developed for such operations and good results are reported. The electrode spindle is inverted, and is mounted beneath the work table in such a way that it is free from play, and is rigidly aligned. In operation, the spindle is passed through the rough-machined opening in the work, the electrode is attached, and the spindle is then fed downwards. A plastics bubble encloses the top of the work and the electrode, and the electrolyte is drawn upwards past the gap between the electrode and the bore, and re-circulated by way of a suction pipe connected to the bubble. (MACHINERY, 92—10/1/58.)

Skinner Unit Heads for Transfer Machines P. 77

The unit heads, here described, are intended to be incorporated in special machines for performing drilling, reaming, tapping, and light milling operations. With the No. 2 head, holes up to ½-in. diameter can be drilled in mild steel, and the spindle has a maximum cam-operated stroke of 2 in. The No. 3 head, which is driven by a stator-rotor unit of 1 or 2 h.p., will drill holes up to ¾ in. diameter in steel, and the maximum stroke is 6 in. An illustration is included of an orbital transfer machine incorporating these heads, which enables operations to be performed on five faces of a workpiece. (MACHINERY, 92—10/1/58.)

Equipment for Automatically Coating Washing Machine Tubs with Slip.....P. 79

At the first stage in the process of enamelling tubs for home laundry washing machines at the works of the Whirlpool-Seeger Corporation, U.S.A., a base coat of slip must be applied smoothly. Previously, dipping was carried out by hand, but the tubs are now moved round a loop track on spider-type carriers. Before the tub is dipped, a slow rotation is automatically started, and this motion is continued during the subsequent draining period. After the work leaves the dipping tank, it is automatically inclined, and, as it rotates in this position, it is jarred so that any drops of slip fall off and do not produce "sags." (MACHINERY, 92—10/1/58.)

Nickols Automatic Sequence-control Equipment .....P. 87

The Nickols automatic sequence control equipment can be employed for the control of a wide range of machines, and its use on a modified capstan lathe is here discussed. The lathe has been adapted for operation entirely by air cylinders and associated equipment, such as hydraulic check cylinders, solenoid valves, micro-switches, and solenoid-operated contactors. Micro-switches are fitted in positions such that they are operated at the end of the movement of each machine element, and the signal obtained from the completion of each movement serves to initiate the next. After describing the modifications carried out on the machine, the use of the equipment for making a typical capstan product is discussed. This component, which is a pillar bolt requiring the turning of two diameters, chamfering, centre-drilling, threading, forming, and parting off, is produced entirely automatically in a cycle time of 65 sec. Apart from the normal time required for tool setting, the connection of the control equipment for the cycle is completed in a further period of only 10 min. The modifications necessary to adapt a standard machine tool are such that the machine can readily be restored to its original state. (MACHINERY, 92—10/1/58.)

Aircraft Manufacturing Practice—A Review of British Industry.....P. 97

In this article, the second based on a paper presented by Mr. L. G. Burnard at the recent Aircraft Production Conference, organized by the Institution of Production Engineers, reference is made to various methods and items of equipment that have been developed to facilitate the production of aircraft pipework. A machine for cutting templates from loft plates is also described. Techniques for forming titanium are considered, and various procedures for welding this material are discussed. Other subjects covered in the article include chemical production methods—including a method of reclaiming worn files—the elimination of stress raisers, the use of stainless steel honeycomb material, metal adhesive bonding, and the application of plastics to aircraft structures. (MACHINERY, 92—10/1/58.)

The Steel Supply Position

At various times during the post-war years, the activities of certain branches of the metal-working industries have been hampered, to a greater or lesser degree, by scarcity of home supplies of steel in some forms. One result of this situation has been the not infrequent necessity to supplement the deliveries of home-produced materials by the purchase of imported steels at higher prices. Where this course has been followed, manufacturers' costs have inevitably been inflated. At the same time, the consequent rise in the value of steel imports has adversely affected the balance of external trade. Last year, the general position improved considerably from the standpoint of the steel user, and while it would be premature to suggest that all scarcities of British-made materials are likely to be overcome in the near future, it is improbable that they will again present such serious problems as in the past.

The 1957-58 supply situation is effectively reviewed in the latest issue of *Steel* (published by The British Iron and Steel Federation) and it is shown that, even before the credit squeeze was tightened, and the 7 per cent bank rate introduced, steel consumption had begun to fall. During the first half of the year, it is estimated, the requirements of British users accounted for about 300,000 ingot tons less than in the corresponding period of 1956. In the third quarter, this trend was reversed, partly by reason of the fact that the 1956 figure was relatively low. Nevertheless, for the first nine months of the year it appears that about 1·5 per cent less steel was used than in 1956. Although the change was slight, it must be borne in mind that steel production capacity continued to rise as a result of the various development schemes within the industry. Consequently, the effect on the overall supply position was substantial. During the early months of the year, stocks were considerably augmented, but it appears that this trend was not maintained in the third quarter. With British steel more plentiful, moreover, imports fell from the equivalent of 1,480,000 ingot tons in the first nine months of 1956 to 702,000 ingot tons in the 1957 period.

By reason of increased stocking and reduced imports, it was possible to increase home deliveries of British steel by 1·8 per cent in the nine-month period of 1957 as compared with 1956, but this process obviously cannot continue unless demand begins to rise again. Evidently, therefore, British steel producers must look increasingly to export markets—at least in the immediate future—for outlets, if the growth of output is to be maintained. So far, considerable success has beein achieved in this direction, and it is anticipated that the final figures for the year will show exports equivalent to 4 million ingot tons, as against 3·3 million for 1956.

The effect of the changing steel supply position is clearly reflected in the trade and navigation accounts for the first 11 months of 1956 and 1957. In the former year, imports and exports under the heading "iron and steel" were valued at £99·2 million and £159·2 million respectively, whereas in 1957 the figures were £73·7 and £175 million. As between the two periods, therefore, the favourable balance rose from £60 million to £101·3 million. In this connection it should be noted, however, that for the months of October and November last, imports were at an annual rate of £97·4 million, or only slightly less than the 1956 figure. That the supply and demand position, as regards certain classes of steel materials, is still fairly delicately poised, moreover, will be evident when the following figures are considered. During the first six months of 1957, a total of 84,589 tons of "plates and sheets—uncoated," valued at £5·97 million was imported, whereas for the month of November alone the figures were 41,346 and £2·84 million.

As a result of the recession in demand, the estimated total of steel production in 1957 was 21·7 million tons, as compared with 20·6 million tons in 1956, whereas the capacity available last year would have permitted an output of 22·4 million tons. Owing to continued expansion, the steel industry could, it is estimated, produce 23·5 million tons in the current year, but it is believed that the actual output will be well below this figure, although it should somewhat exceed the total for 1957. No substantial increase in the home demand for steel is anticipated before the closing months of this year at the earliest, and it is considered not unlikely that aggregate deliveries will be less than in 1956. The additional productive capacity may be partly absorbed by further replacement of imports by British-made steel, and in the steel industry itself it is planned to use less imported semi-finished material. For the most part, however, as has already been indicated, it will

(*Continued on page* 112)

The Production of Components for Lambretta Motor Scooters

Methods Employed in the Innocenti Works at Milan, Italy

The company which is now known as Innocenti Societa Generale per l'Industria e Meccanica, S.p.A., occupies a large plant in the Lambrate district on the outskirts of Milan, and has its head office in that city. Established in Rome in 1933, as Fratelli Innocenti, this company adopted the present title in 1942. In the early days, a small factory in Rome was supplemented by another at the site now occupied in Milan, and the company was at first mainly concerned with the fabrication of such items as grilles, railings, scaffolding and irrigation equipment, which were made largely from bought-out steel tubes. As the company extended its activities, it was decided to manufacture the steel tubes required, and an up-to-date plant for this purpose was established at Apuania. Production of seamless steel tubes at this plant, under Innocenti-Calmes patents, has enabled the company to compete in numerous overseas markets. Many of the factories occupied by the firm were damaged during the second world war, and afterwards it was decided to concentrate activities at the Lambrate, Milan, works, where there was ample room for expansion, and a plentiful supply of the skilled labour required.

THE LAMBRATE WORKS

At Lambrate, the factories are built on a site covering an area of about 144 acres, which is of rectangular shape, measuring approximately 1,400 by 500 yards. Here, the business is organized as two virtually separate parts, known as the motor and mechanical equipment divisions. A total of approximately 4,000 people is employed, including 800 staff. The mechanical equipment division provides employment for about 1,500 men, of whom some 400 are engaged solely on maintenance of all the machine tools in the entire factory, and the remainder on production. Among the varied activities of the mechanical equipment division may be mentioned the design and construction of complete installations for the production of seamless steel tubes under Innocenti-Calmes patents, and other tube-making plants; the building of machines and equipment for the iron and steel industry, such as the large plant now under construction—to be installed near Rio Orinoco, Venezuela—for the production of about 700,000 tons of steel ingots, and about 500,000 tons of finished products, per year; the production of hot ingot-peeling machines; the construction of Sendzimir planetary rolling mills, one of which recently completed and installed in Milan, is now engaged on the reduction of strip of 1 metre width from a thickness of 90 mm. to only 1 mm. in a single pass; the building of large machine tools, including boring and milling machines under licence from C. W. Berthiez, and large presses of up to 6,000-tons capacity under licence from the Clearing Machine Corporation; and the weld-fabrication of large structures, which are produced in a shop well-equipped for torch-profiling, heat-treatment, automatic welding, and shot-blasting and various other operations.

MOTOR DIVISION

The motor division of the Innocenti company occupies between one-third and one-half of the covered area of the Lambrate factory, and provides

employment for about 2,500 people on a double shift system. Products of this division include the Lambretta motor scooter, which is made with engine capacities of 125 and 150 c.c., one of the latter size being shown in the heading illustration. In addition to the scooter, three-wheeled vehicles for commercial and other applications such as the transport of components in factories, are made in both open and cabin designs. Another scooter, recently added to the range, is fitted with an efficient power unit of 175 c.c. capacity, which will form the subject of a later article. In addition, the division produces an auto-cycle or mo-ped known as the Ribot, with an engine capacity of only 48 c.c., which has already set up a record at the Monza race track by running for 100 consecutive hours at an average speed of 37·5 m.p.h. Production of motor scooters, three-wheelers, and mo-peds, at the rate of about 500 vehicles per shift, is carried on in three main buildings, which house a foundry and forge; a machine shop for the engine and other components, including an assembly track for the engines; and a press shop in which the scooters and other vehicles are finally assembled and finished. More than 1½ million vehicles have so far been made, a large percentage of which has been exported. Reference will be made in a subsequent article to the activities of the foundry, in which the shell moulding process is exclusively employed for the production of finned cylinders. First, however, attention will be directed to the machine shop for engine components and some of the methods adopted.

The machine shop, in which engine and other components for motor scooters are produced, is a rectangular building, with an assembly track for the engines extending along one long side, as seen in Fig. 1. Webbed girders of reinforced concrete support the roof of each bay, and rest on pillars of the same material, the smooth surfaces of which do not harbour dust, and are easy to keep clean and to paint. In consequence, the interior of the building is remarkably light, and gives an impression of spaciousness, which would not be conveyed by a shop of similar dimensions but of conventional construction. Large windows in each roof bay permit ample light to enter the shop. At one side of the assembly track there is a stores for those components which are bought out, or are received as sub-assemblies, and, on the other side, the machines are arranged in rows transversely across the shop, so that most of the finished components arrive at the track, ready for fitting to the engines, at the points at which assembly is most conveniently carried out. With the exception of cylinder castings, which travel from the foundry on a special conveyor, supplies, in the form of stampings, pressings, castings, forgings, and bars, arrive on the side of the shop remote from the assembly track, and are stored in bays on that side until they are fed into the appropriate machining lines. For many of the larger or heavier components, continuously-moving conveyors, or low metal-covered benches on which parts may readily be pushed along, are provided, and for easily-rolled parts, such as pistons, multi-channel inclined transfer chutes are installed between the machines.

At the end of the shop at which the assembly

Fig. 1. This View of the Machine Shop for Lambretta Engines and other Components Shows the Engine Assembly Line, which Extends Down One Long Side of the Building

line starts there are areas devoted to single- and multi-spindle automatics, and to capstan and turret lathes. Hydraulic copying lathes are also installed here, as well as in the other machining lines mentioned, and there are batteries of gear-cutting machines for the transmission gear blanks produced on the automatic lathes. Where a hardening operation is specified for a particular component, the heat treatment is carried out in the line, quenching presses being provided where required. When the completed engine units reach the end of the assembly track, they are removed from the special support brackets, and hung on a conveyor on which they travel to another building for fitting into the scooters. This conveyor passes, first, through a test house, equipped with dynamometers on which the engines are subjected to a running test to ensure that they will deliver the advertised power (6 h.p. for the 150 c.c. size). Engines, returned to the conveyor, are then carried through an underground tunnel into the main assembly shop. Underground tunnels are also provided for the work-people to walk between the shops and the canteen, so that the factory roads are unobstructed, and the workers are not exposed to inclement weather in winter.

THE LAMBRETTA MOTOR SCOOTER

The Lambretta LDB 150 c.c. mark 3 motor scooter, shown in the heading illustration, has a weld-fabricated, steel-tube frame, to which are secured the pressed covers and mudguards. Front wheel suspension is by means of trailing links incorporating coil and rocker springs, and the interchangeable wheels, for tyres of 4·00 by 8 in. size, have rims of the split type for ease in tyre fitting and removal. The engine, gearbox and transmission are made as a single unit, as shown in Fig. 2, and this unit is so mounted in the frame that it can turn to a limited extent about a point just behind the cylinder, against the resistance of a substantial torsion bar and an associated hydraulic shock absorber. Thus, road irregularities are smoothed by vertical movements of the rear wheel, which is mounted at the left-hand end of the unit in Fig. 2. The layout of the power unit is shown diagrammatically in Fig. 3, where the cylinder has been displaced so that the arrangement may be seen more clearly. Aluminium alloy pressure die castings—at present bought out—are employed for the crankcase and transmission housing, also for several other components, and, at the top, the crankcase has an inclined bore to accommodate the spigot-located cast-iron, finned cylinder, to which is fitted an aluminium alloy head. Two double-row ball race bearings within the crankcase support the two-piece crankshaft, which is assembled by means of a force-fitted crankpin. On the crankpin, the big end of the connecting rod runs on caged needle rollers.

At the right-hand end of the crankshaft (viewed from the front) there is a die cast aluminium cooling fan of the centrifugal type, which circulates air through a duct surrounding the finned cylinder to prevent overheating. Adjacent to this fan is a flywheel magneto, incorporating an automatic advance and retard mechanism. On the other end of the shaft is a bevel gear, through which the drive is transmitted to the housing of a multi-disc clutch. This clutch is mounted on the forward end of the main drive shaft, which extends to the rear of the crankcase.

Between the crankcase and transmission housing castings is the 3-speed gearbox, whereby the drive is transmitted to a spring-steel shaft. This shaft is designed to absorb, by twisting, any sudden shocks, as might be caused, for instance, by engagement of the clutch while the engine is

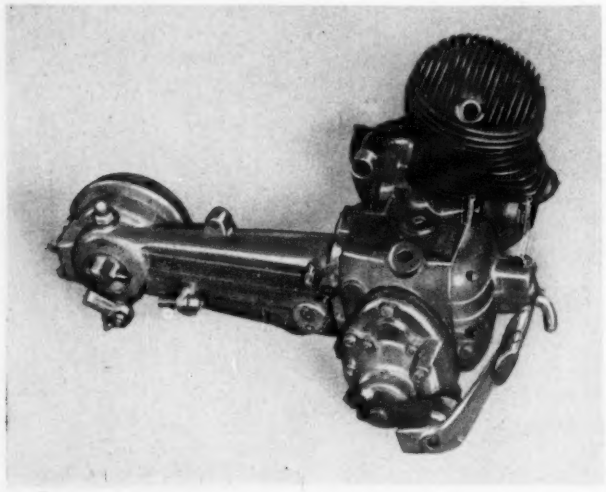


Fig. 2. The Assembled Power Unit for the 150-c.c. Lambretta Scooter. The Crankcase and Transmission Case, also many of the Covers and other Parts are Pressure Die Cast in Aluminium

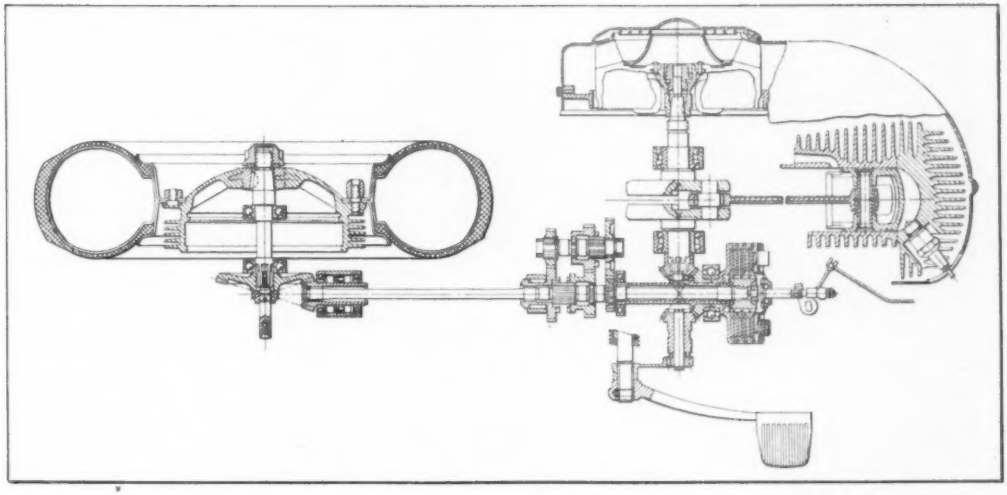


Fig. 3. Diagrammatic Layout of the 150-c.c. Lambretta Engine and Transmission Unit, with the Cylinder Displaced for Clarity, Showing the Disposition of the Clutch, Gearbox, and Final Drive to the Rear Wheel

running at too high a speed, and it has a bevel gear, at the rear end, through which the power is transmitted to a somewhat larger bevel gear on the rear wheel spindle. The latter is carried on two widely-separated ball bearings in the cast housing at the end of the transmission case.

On one side of the crankcase there is a curved lever for kick-starting the engine, and the shaft of this lever carries a toothed segment which meshes with a gear on a shaft in line with the crankshaft. This gear has bevel teeth which mesh with those of the main driving bevel for the clutch housing, so that, as the kick-start lever is pushed down, the crankshaft is turned. Although the kick-start mechanism is still fitted, the latest design of scooter incorporates an electric starter with a Bendix-type drive. The scooter has a wheelbase of slightly more than 50 in., weighs about 250 lb., and will travel up to 100 miles per gallon of petrol and oil mixture. Machining operations on most of the components so far mentioned will be described in this article, and others to be published later in MACHINERY.

MACHINING OPERATIONS ON PISTONS

Pistons for most of the engines produced in the Lambretta works are made by substantially similar methods, and it is intended to describe only the manufacture of pistons for the 150 c.c. size, the capacity of which is actually 148 c.c. The piston employed in this engine has a nominal diameter of 57 mm., and the length of the stroke is 58 mm. A drawing, giving the shape and main dimensions of the piston, is shown in Fig. 4, and it is machined from an aluminium alloy gravity die casting obtained from an outside supplier. From the stores, the castings are delivered in large box pallets to the starting end of the machining line, where they are packed into shallow trays fabricated from thin steel bars, which are designed to allow maximum air circulation round the pistons. Each tray holds 40 pistons in a single layer, and, when filled, is placed in a large oven near the start of the line. The oven is heated initially to a temperature of 410 deg. C., and the pistons are held at this temperature for 30 min., after which automatic temperature control equipment reduces the temperature to 350-370 deg. C. This temperature is maintained for a further 9½ hours, the treatment being designed to release internal stresses in the castings and to stabilize them dimensionally.

Some stages in the machining sequence are shown in Fig. 5, the first operation being exemplified by the piston at the left-hand end of the rear row. Performed on an AMI 600 fine-boring machine supplied by the Italian firm of Cimat, Turin, the first operation on the piston provides for rough-turning the outside, spherical-turning the end, boring the gudgeon pin bosses and facing and boring the skirt. A general view of the Cimat machine is given in Fig. 6, and it will be

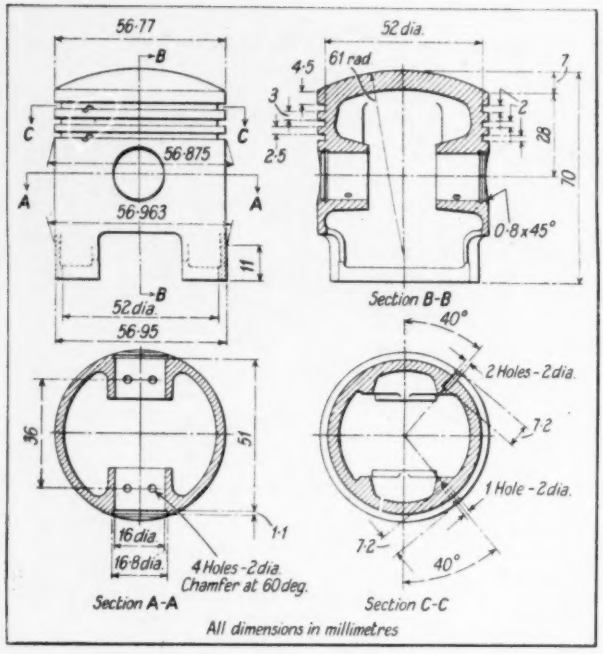


Fig. 4. The Piston for the 150-c.c. Lambretta Engine, which is Machined from an Aluminium Alloy Gravity Die Casting, and Finally Ground to a Combined Tapered and Oval Form

seen that it is of conventional construction, with a central table carrying work-fixtures, and two spindle-heads at each end, the latter being mounted on bridge-members, so that the table can move beneath them. The table feed is hydraulically powered, as are the clamping arrangements for the pistons, which are loaded at the right-hand end for the initial turning operations, and then at the left, for the operations on the skirt and gudgeon pin bores.

A close-up view of the tooling and clamping arrangements at the right-hand end of the machine is given in Fig. 7, and it is designed to carry out similar operations on pistons for the 125 and 150 c.c. capacity engines, the smaller piston being loaded at the front and the larger at the rear, at both ends of the machine. At the right-hand end of the machine, each piston is loaded skirt-end towards the spindle, and is pushed into contact with axially-floating tapered bushes, which support the skirt against the cutting tool thrust. Then, one of the ball-handled levers at the lower right is turned, to open a valve that controls the supply of pressure oil to the cylinder at the outer end of the spindle. This action results in movement of a draw-bar within the spindle, with the result that pads, with serrated faces, are expanded against the inside of the piston, to clamp it in position. The two castings turned at the previous cycle are then loaded at the left-hand side, as will be explained later, and, next, the cycle start button is pressed.

During the automatic cycle of the machine there is a rapid traverse of the table to the right, followed by a slow cutting stroke, and the table is then moved to the left, where the motions are repeated. Tool-holders, with provision for transverse adjustment, are mounted on the prismatic ways of a substantial casting secured to the table, and each carries a single inverted carbide-tipped tool for rough-turning the outside of the piston, leaving about 1 mm. on the diameter for finishing operations at a subsequent stage.

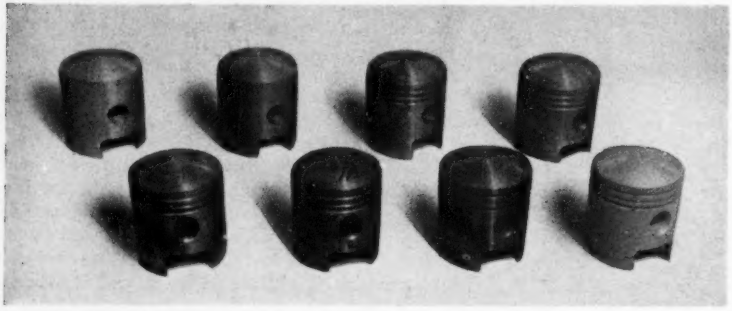


Fig. 5. Eight Stages in the Production of the 150-c.c. Lambretta Engine Piston. After the Final Grinding Operation the Piston is Tin-plated to Facilitate Running-in

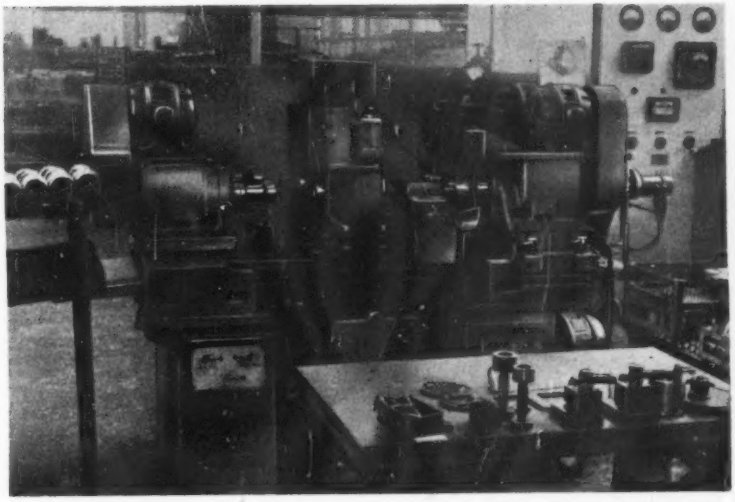


Fig. 6. This Cimat AMI 600 Fine-boring Machine is Employed for Cylindrical and Spherical Rough-turning the Outside of the Piston, Boring, Facing and Chamfering the Skirt, and Rough Boring the Gudgeon Pin Hole. Two Sizes of Piston are Handled

During the cylindrical turning operation on the piston, the domed end is also machined. A bracket *A*, fixed to the platform of each spindle-driving motor, carries a small hydraulic cylinder, located with its ram vertical. On the face of each cylinder there are guideways for a vertical slide, the upper portion of which projects to the rear, above the cylinder, and is connected to the end of the ram. Secured to the further side of each cylinder there is a bracket, which extends downwards beyond the level of the piston centre-line, and has a horizontal bore at that level. A pin in this bore provides an anchorage for a curved lever, the end of which is seen at *B*. This end is thickened, and is drilled and tapped to accommodate a tool bit and clamping screws, the distance from the mounting point to the tool bit being 62 mm. The vertically-moving slide on the front of the cylinder *A* is connected to the lever *B* by a short link, so that, as the slide is moved down by the hydraulic cylinder, the tool in the lever *B* is caused to move through an arc of 62-mm. radius, machining the end of the piston to that radius, and leaving about 1 mm. on the surface for finishing. For these two turning operations, a spindle speed of 620 r.p.m., and a feed rate of about 1 mm., per rev. are employed.

The left-hand end of the machine is seen in the close-up view, Fig. 8, which shows the hydraulically-operated fixture employed to hold the two pistons. Each piston is loaded, with the skirt end

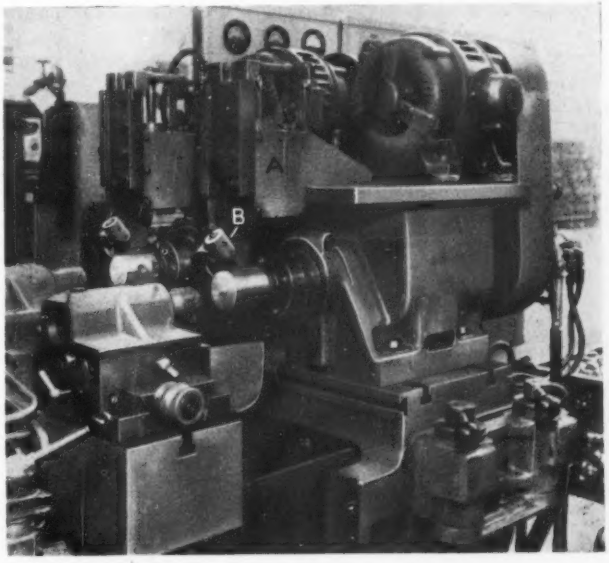


Fig. 7. Close-up of the Tooling at the Right-hand End of the Machine in Fig. 6, Showing the Toolholder *B* which is Moved Through an Arc by the Vertical Motion of the Hydraulically-operated Slide *A*

facing the tools, in a collet type chuck with ten segments. Location of the piston, with the gudgeon pin bores vertical, is effected with the aid of a finger which engages the cast slot in the skirt. This slot is in line with the bores, and the finger, which is held in a small vertical housing *C* on the front face of the fixture, is spring-loaded into the raised position. One of the valves at the front of the fixture is operated to close each collet, and the locating finger is then retracted downwards by hand, and locked by turning its ball-handle sideways, so that it enters an upwardly-inclined retaining slot in the side of the housing. On top of each fixture at the left-hand side of the table is mounted a housing for a hydraulic cylinder. Passing through the ram of each cylinder there is a spindle carrying a single-point cutting tool, the axis of the spindle being aligned with the centre of the gudgeon pin bore when the piston is located and clamped as described. Each spindle is driven at a speed of 1,240 r.p.m., by a 0·35-h.p. motor on one side of the cylinder housing. It is fed at 0·17 mm. per rev. when trip dogs on the table depress plungers at the front of the machine, as the table is fed to the left during the automatic cycle of the machine. Approximately 0·08 mm. is left in the gudgeon pin bores for the finishing operation.

The two spindles at the left-hand side of the machine are also started by movement of the table towards the left, and each has four cutting tools which are employed for boring the skirt to a diameter of 51 mm. for the larger piston, facing the end and chamfering the inside and outside corners, as the table is fed up to a fixed stop. The spindles are run at a speed of 750 r.p.m. for these operations, and these spindles, also those at the right-hand end of the machine, are individually driven by motors of 1·6 h.p. No coolant is employed. The floor-to-floor time for the complete series of operations on one piston of each size is 78 sec. Machined pistons are placed in the channels of an inclined metal chute at the left of the operator's position, and roll down to a stop adjacent to the loading station of the next machine in the line.

SPECIAL INNOCENTI DRILLING MACHINE

Employed for drilling a total of seven holes, each of 2 mm. diameter, this next machine is shown in Fig. 9, from the loading position. Two of the holes are drilled in each of the gudgeon pin bosses for oil circulation, and must also be chamfered at 60 deg. on the outside of the bosses. The other three holes are drilled in the positions that will later be occupied by the piston ring grooves, as shown in Fig. 4, and small pins are subsequently inserted to prevent the rings from turning in service.

Built by the machine tool department of the mechanical equipment division of Innocenti, the machine in Fig. 9 has a weld-fabricated steel-plate base, of rectangular shape, with an extension on the operator's side to carry the control panel. At the centre, there is a 6-position indexing table, with a detachable circular plate carrying locating fixtures for the pistons, each of which makes two complete circuits, one in an upright position, and one while lying on its side. Indexing of the table is effected by turning the ball-handled lever *D*, which retracts a spring-loaded locating pin. At the end of its movement, the lever operates a micro-switch to start a motor in the base of the machine. This motor drives the table, at a slow speed, through a slipping clutch, and the lever *D* is released after the table has started to turn, so that the locating pin rides on the under-side of the table, and is

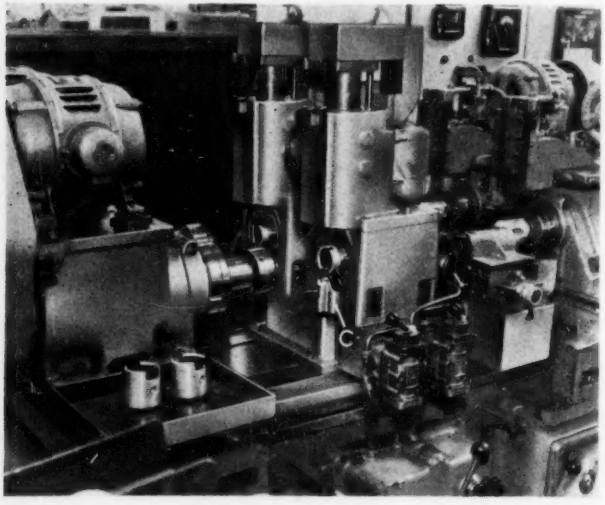


Fig. 8. In this View of the Tooling at the Left-hand End of the Machine in Fig. 6 the Vertical Boring Spindles for the Gudgeon Pin Holes and the Method of Clamping the Pistons are Seen Readily

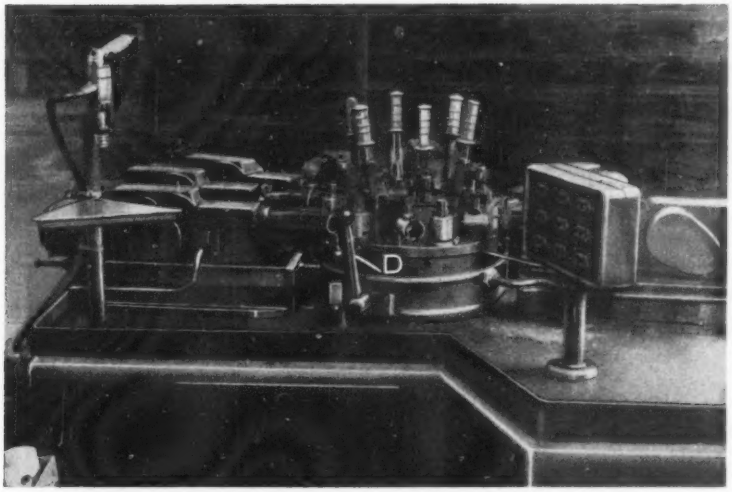


Fig. 9. Special Innocenti-built Machine for Drilling Seven Holes, Each of 2 mm. Diameter, in the Gudgeon Pin Bosses and the Piston Ring Grooves. Each Piston Makes Two Complete Circuits of the Machine

pushed up, into engagement with the next index hole, by the spring, at the same time cutting off the current supply to the motor. In the table fixtures, each upright piston is spigot-located by the skirt, angular positioning being obtained from projections which enter the skirt slots. The other piston rests in a semi-cylindrical cradle, and is located by a pin which enters the gudgeon pin bore. Both pistons are then secured by a single toggle clamp mounted on a block at the rear, and fitted with a floating clamping beam, carrying shaped pads which conform to the outer contours of the pistons. Two interchangeable plates, one for small and one for large pistons, are provided for this machine, that shown being for the large size.

Arranged round the table, which is indexed in an anti-clockwise direction, are seven, small, single-spindle, unit heads of Innocenti design. Similar heads are also employed elsewhere in the factory, as will be indicated in later articles in this series. A close-up view of one of these heads, from which the cover plate has been removed to show the feed mechanism, is given in Fig. 10. From this view, it will be seen that there is an edge cam *E*, of approximately circular shape, which is driven, by a small gear, from the main drill spindle, at a speed of about one revolution in 45 sec. A member *F*, connected to an operating fork for the spindle, has a roller in its slotted end which makes contact with the cam periphery, and, in the withdrawn position, this roller is accommodated in a deep recess in the cam, as shown. At the beginning of the automatic machine cycle, which is initiated by pressing a button, the spindle motor is started, and drives the spindle at 4,000 r.p.m., through step-up gears in a box behind the cam position. The cam starts to turn at the same time, in a clockwise direction, and as the roller moves along the steep slope immediately above it in Fig. 10, the drill is advanced quickly towards

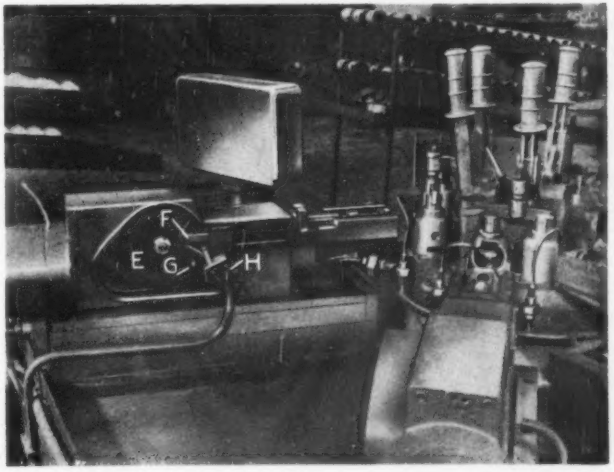


Fig. 10. Close-up View of One of the Unit Heads on the Innocenti Piston-drilling Machine, Showing the Feed Cam which Provides for Withdrawal at Three Points for Swarf Clearance

the work. The remainder of the cam surface is designed to feed the drill at the rate of 0·0004 in. per rev., but, at intervals round the cam periphery, there are three semi-circular recesses, which cause the spindle to be retracted slightly, for swarf clearance. After the cam has completed almost one revolution, a pin *G* makes contact with a roller in the end of a plunger for operating a limit switch *H*. The current supply to the spindle driving motor is thus cut off, and the cam then coasts to the position shown, at which the spindle is fully withdrawn. Quick-spiral drills are employed to facilitate swarf clearance, and are supported by spring-loaded bush plates. Soluble oil coolant is supplied to each of the drills by a ring manifold, which partially surrounds the table. The cycle time for the machine is 48 sec.

FINE-TURNING AND GROOVING

Another Cimat machine, somewhat similar in design to that described earlier, is next employed for semi-finish turning the outside of the piston, finish-turning the spherical end, and rough-forming and finishing the ring grooves. A general view of this machine is given in Fig. 11, and, like that previously discussed, it is employed for operations on pistons of both sizes. With a floor-to-floor time of 2 min., this machine is considerably slower than the drilling machine, and advantage is taken of this fact to build up stocks of pistons, so that both sizes are available together. Thus, some of the pistons from the drilling machine are loaded into large box pallets, such as that seen in the foreground in Fig. 11, and some are placed in the channels of an inclined chute. The numbers of pistons of each size drilled are adjusted to maintain a steady supply for the Cimat machine. Pistons are first loaded at the left-hand side of the machine—the larger diameter piston at the front—and the first operation provides for fine turning the spherical end to the 61-mm. radius shown in Fig. 4. A close-up of the tooling at the left-hand side of the machine is given in Fig. 12, and each piston is located, by means of the skirt bore, on a spindle register, and is clamped by a draw-bar which is connected to the piston by a dummy gudgeon pin. Valves at the front of the machine, as seen in Fig. 11, control the hydraulic cylinders for the draw-bars.

Spherical turning of the piston ends is effected by tooling similar to that employed at the roughing stage, a hydraulic cylinder, mounted on a bracket above the spindle, feeding a lever-mounted tool downwards, in an arc, by means of a link. As soon as the tool has been retracted, the machine table is fed to the left. On the table are mounted two tool slides for the left-hand side of the machine, which are separately adjustable by means of knurled wheels with scales. The slides carry tool-holders for single-point turning tools, whereby the outside of the piston is semi-finished—in readiness for finish-grinding—to a diameter of 57·5 mm. At the end of the movement of the table towards the left, a centre-drill, carried in each tool-holder, is applied to the centre of the spherical end of the piston, to provide for support during the subsequent grinding operation. For these turning operations, a spindle speed of 950 r.p.m., and a feed of 0·07 mm. (0·0032 in.) per rev., are employed.

Rough-forming, followed by finish-facing the piston ring grooves, to a width of 2 mm. and a depth of 2½ mm. for the larger piston, is carried out at the right-

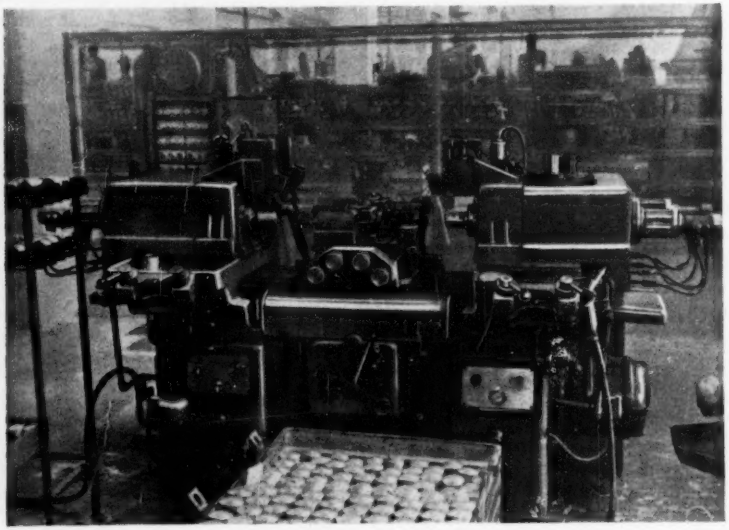


Fig. 11. On this Cimat Machine, the Outside of the Piston is Semi-finish Turned, the Spherical End is Finished, and the Ring Grooves are Rough-formed and Finished on Two Sizes of Piston

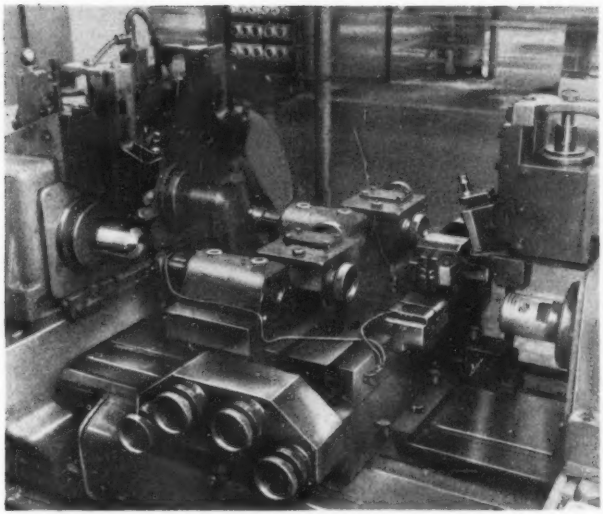


Fig. 12. Close-up View of the Tooling on the Machine in Fig. 11, Showing the Arrangement for Spherical Turning at the Left. At the End of the Cylindrical-turning Movement of the Table a Centre Drill is Applied to the Spherical End of Each Piston

hand end of the machine, to which the semi-finish turned pistons are transferred at the next loading operation. Here, the pistons are again loaded with the smaller end at the rear, the locating and clamping arrangements being similar to those at the left. The smaller piston has two ring grooves, and the larger, three, and a close-up showing details of the tooling for machining these grooves is given in Fig. 13. Two tool-slides, again separately adjustable by knurled knobs at the front of the table, carry the tools, of which there are three sets for each piston. Projecting, from the horizontal surface of a bracket *J*, on the tool slide, there are two sets of tool bits, one behind the other, each set comprising three bits. Each tool bit in the leading set is slightly narrower than the required finished width of the ring groove, and serves to form the groove to depth, when the table is moved to the right against a stop, and is then traversed towards the front of the machine. Towards the end of this traversing movement, the tool bits of the second set operate on the edges of the grooves to impart a slight chamfer on each side.

Behind the bracket *J*, there is a vertical bracket *K*, which carries four tool bits, in pairs, one above the other. Unlike the other carbide-tipped tools, for grooving and chamfering, these tools are of solid carbide, and they are employed to take very light facing cuts on the sides of the two outer ring grooves. Above the spindle housing is mounted a hydraulically-operated vertical slide, with a tool-holder set at an angle to provide a small amount of lateral adjustment. In this holder is carried a further pair of solid carbide tool bits, which are employed for the finish-facing operations on the sides of the central groove. The tooling for machining the smaller piston is similar to that described, except that this upper slide is not used, since, in this instance, there are only two grooves.

For the ring-grooving operation, a spindle speed

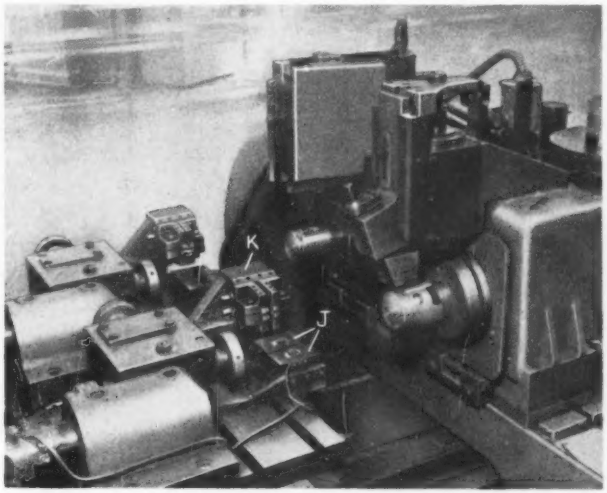


Fig. 13. Rough-forming and Chamfering of the Piston Ring Grooves is Carried Out by Three Tools in Each of the Holders *J*, when the Table is Moved to the Right Against a Stop and then Fed Transversely. The Grooves are then Finish-faced by Tools in the Holder *K*, and Another Above the Piston

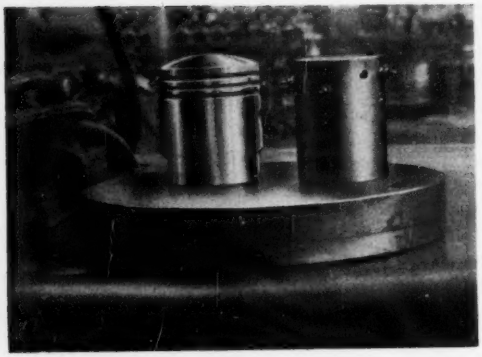


Fig. 14. A Quick Check on the Positions of the Three Ring Grooves in the 150-c.c. Engine Piston is Carried Out with this Gauge which has Horizontal Pins at the Heights Specified for the Grooves

of 735 r.p.m. is employed, and the tools are fed at the rate of about 0·0032 in. per rev. No coolant is employed on this machine, but swarf is blown from the tools by jets of compressed air, delivered through copper tubing.

A rough check on the positions of the piston ring grooves, in relation to the lower end of the skirt, is carried out at this stage on sample pistons, with the aid of the equipment shown in Fig. 14. A steel cylinder, the base of which is square with the outside, is fitted with a number of gauging pins of such a diameter that they will just enter grooves at the correct heights above the base. The gauge and the piston are placed on a surface plate, and the grooves are presented to the pins in succession. "Go" and "not-go" gauges are also provided for checking the width, which is held to limits of +0·07/+0·04 mm. for the top groove, and +0·07/+0·02 mm. for the two remaining grooves. Limits on the 52 mm. nominal diameter at the bottoms of the three grooves are −0·140/−0·330 mm.

FINISHING THE GUDGEON PIN BORES

Another Cimat fine-boring machine, of a design similar to that just described, is next employed for cutting the circlip grooves and finish-boring the gudgeon pin holes. The fixture on this machine again provides for both sizes of pistons, the larger being accommodated at the rear and the smaller in front, and a close-up view is given in Fig. 15, from slightly to the left of the operator's position. For loading, the locating mandrel *L* is first inserted in the gudgeon pin bore and the piston is placed in the fixture in the inverted position, with the end of the mandrel engaging an internal bush in the fixture. In this position, the piston skirt is located by a register above, and operation of one of the valves on the side of the fixture then raises the end of a hydraulically-operated ram into contact with the crowned end of the piston, to clamp it. Withdrawal of the mandrel completes the operation. Two pistons, from the previous operation, are loaded at the left-hand side of the fixture, the two pistons from this position being transferred to the right-hand side. For the first operation, the table is fed to the left into contact with a stop. Each tool-holder is mounted in a slide, by which it can be fed outwards, and carries two grooving tools for the 1·1-mm. wide by 0·4-mm. deep circlip grooves, and a single tool for cutting a 45-deg. chamfer at one end of the bore. As soon as the table comes into contact with the stop, the tool-holders are fed outwards slightly and then retracted, before the table is fed to the right.

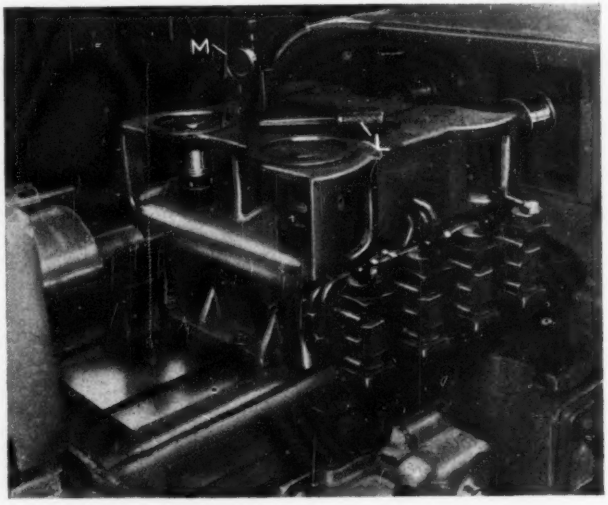


Fig. 15. Tools at the Left-hand Side of this Machine are Employed for Cutting the Circlip Grooves and Chamfering One End of the Gudgeon Pin Bore. The Spindles on the Right are Equipped for Finish Diamond-boring the Gudgeon Pin Hole and Chamfering the Other End

In loading each piston in the right-hand side of the fixture, the chamfered end of the bore is placed on the side furthest from the tools. Each of the spindles at the right-hand end of the machine carries a carbide and a diamond tool, for successive semi-finish and finish boring cuts, also a carbide tool for producing a 45-deg. chamfer at the end of the bore. For cutting the circlip grooves, a spindle speed of 1,240 r.p.m. is employed, and for finish boring, the carbide and diamond tools are run at 4,900 r.p.m., and the table is fed at 0·017 mm. (0·0007 in.), per rev. The floor-to-floor time for operations on two pistons on this machine is 2 min. 18 sec.

Accurate setting of the tools employed on this machine, and certain others in the works, is carried out with the aid of the magnetic V-block *M*, which is fitted with a dial indicator. The strength of the magnetic field is such that the V-block will remain in position on the spindle on which it is placed, and the setter can use both hands for the adjustment of the tool. Widely-spaced divisions, corresponding to 0·01 mm. (0·0004 in.), are provided on the dial. The width of the circlip grooves is held to limits of $+0·2/-0·0$ mm., and the largest diameter to 16·8, $+0·2/-0·0$ mm. On the gudgeon pin bore diameter of 16 mm., the limits are $\pm 0·003$ mm., which is equivalent to a total tolerance of 0·00024 in. on a diameter of 0·63 in.

AIR-OPERATED FIXTURE FOR INSERTING PINS

After the gudgeon pin holes have been fine bored, the pistons are transferred to a standard centre lathe, fitted with a collet chuck, on which the skirt register is bored to 52 mm. diameter, and the end chamfered. Then, the pistons are passed to the special-purpose air-operated fixture shown in Fig. 16.

This fixture is employed to insert three small knurled brass pins in the holes previously drilled for the purpose, one in each piston ring groove. The pins are of such a length that, when they are pushed home, their outer ends are below the surface of the piston wall. In the outer pair of ring grooves, the pin holes are in line, one above the other, and the hole in the central groove is displaced by 100 deg., so that, on assembly, the piston ring gaps are permanently staggered. In the fixture, the piston is loaded on to a spigot, which enters the skirt register, and angular location is provided by a projection which engages one of the slots in the skirt. At each side of the position occupied by the loaded piston, at the front, there are steel blocks *N*, containing air cylinders with their axes horizontal. The rams of these cylinders

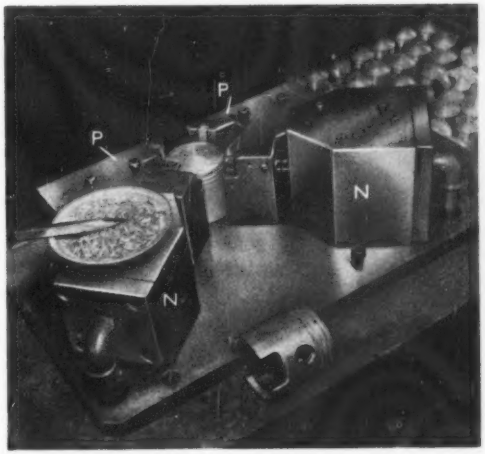


Fig. 16. Air-operated Fixture for Inserting Small Knurled Brass Pins, to Prevent the Piston Rings from Turning, in the Three 2-mm. Holes Previously Drilled in the Ring Grooves

project towards the piston, and the latter is partially surrounded by two more steel blocks *P*, cut away at the top to facilitate loading.

At the positions corresponding to the pin holes in the piston, the blocks *P* are fitted with bushes, which extend almost into contact with the piston walls. The block at the right has two bushes, one vertically above the other, and that at the left has one bush, at 100 deg. from the other two. Punches, attached to the rams of the air cylinders, can slide in the bushes, and the blocks *P* are cut away to expose each bush. In the side of the portion of each bush thus exposed, there is a slot communicating with the bore, through which the small brass pin can be inserted by the operator, with the aid of tweezers.

After loading the piston and placing a brass pin in each bush, an air valve at the side of the machine is operated, to admit air to the rear of the piston in each cylinder, so that the punches are advanced to press the pins home. Release of the air valve reverses the direction of the air supply to the cylinders, whereupon the punches are retracted, and the piston can then be unloaded. Support, against the pressure exerted by the punches, is afforded by angular surfaces on the blocks *P*, on the further side of the piston. Strips of resilient material are let into slots in these faces, in order that the sides of the piston are not marked. These strips, and the bushes for the pins, are replaced when pins are to be inserted in pistons of the smaller size.

FINISH-GRINDING THE OUTSIDE PROFILE

The outside of the piston is next finish-ground on the Fortuna-Werke, A.G. (Vaughan Associates, Ltd.), form-grinding machine shown in Fig. 17. On loading, a dummy gudgeon pin, inserted in the piston, is engaged by a forked driver, when the piston is thrust against a tapered register on the end of the work-head spindle by the lightly spring-loaded tailstock centre. The entire work-head, with its driving motor, is pivoted on the table, and is pulled down at the front by a coil spring, so that a cam *R*, in a recess beneath the head, is held in contact with a roller in a bracket on the table. This cam is permanently geared to the work-spindle, so that it rotates at the same speed, and the motion which it imparts to the work-head causes the piston to be ground to an oval shape, such that the major axis, at 90 deg. to the gudgeon pin bore, is 0·05 to 0·07 mm. (0·002 to 0·0028 in.) larger than the minor axis. In addition to this ovality, the piston is required to be stepped in increments of 0·020 mm. (0·0008 in.), on the three diameters above and between the ring grooves, also curved in profile between the lowest ring groove and the bottom of the skirt. The largest diameter for this portion is just below the gudgeon pin bore, where the piston measures 56·963 mm. Other dimensions are shown in Fig. 4.

These various diameters on the piston are obtained by form-dressing the grinding wheel, which is of sufficient width to enable the full length of the piston to be plunge-ground. Form-dressing is carried out with the aid of equipment mounted on a horizontal slide above the wheel, the position of the dressing diamond in relation to the wheel periphery being controlled by means of a plate cam, one end of which can just be seen at *S* in Fig. 17. A special Norton wheel, intended for grinding aluminium, is employed, in conjunction with a soluble oil coolant, and the work runs at a speed of 140 r.p.m. Typical limits held at this stage are ±0·01 mm. (±0·0004 in.), on the diameters located at each end of the skirt portion, and +0·0/−0·02 mm. on the diameters above and between the piston ring grooves. Piston size is controlled by the operator, but the machine works on an automatic cycle, and the floor-to-floor time is 45 sec. per piston.

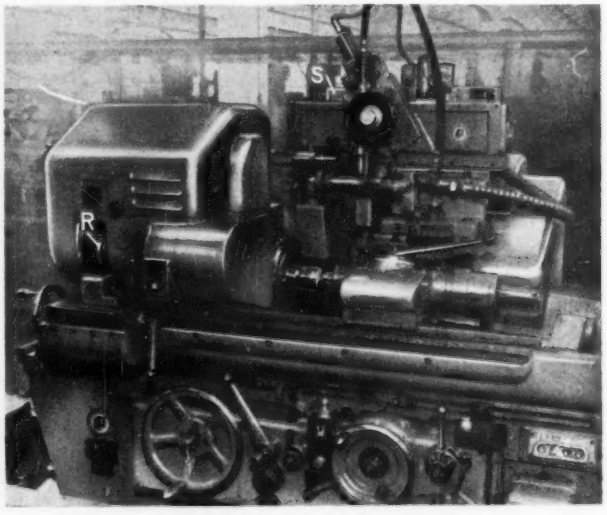


Fig. 17. The Combined Tapered and Oval Forms are Ground on the Outside of the Piston at a Single Operation with this Fortuna-Werke Machine on which Movement is Imparted to the Work-head by a Cam

TIN-PLATING AND FINAL INSPECTION OF PISTONS

Tin plating of pistons to facilitate subsequent running-in is now widely employed, and this treatment is applied by Innocenti. A series of six tanks is provided in the shop, and the pistons are loaded on plastics-coated, steel wire hangers, each of which holds 20, for passage through the various solutions. Degreasing is carried out in the first tank, which contains a caustic soda solution maintained at a temperature of 70 to 75 deg. C., by steam pipes, and the pistons are immersed for a maximum of 45 sec. A 5-sec. rinse in cold water follows, after which the pistons are dipped in a solution of nitric acid for a period of 20 sec. Next, there is a further cold water rinse, and, then, the pistons enter a solution of tin, caustic soda and boric acid, maintained at a temperature of 70 deg. C., whereby a thin layer of about 0·005 mm. (0·0002 in.), of tin is deposited on the exposed surfaces, in a period of about 80 sec. Finally, the pistons are rinsed in almost boiling water for 5 sec., so that they are sufficiently heated to ensure that any water carried over is evaporated.

After the plating treatment, the pistons are passed to the inspection bench seen in Fig. 18.

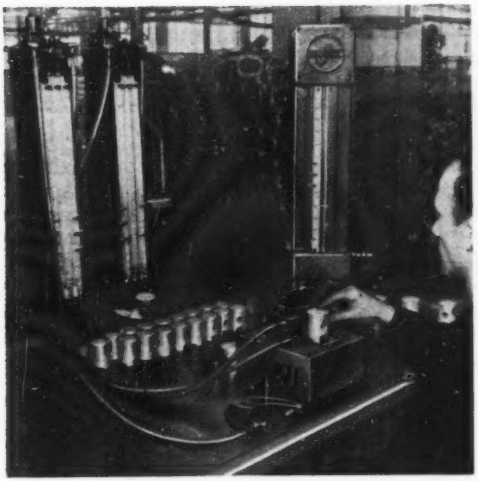


Fig. 18. With this Solex and Innocenti Air-gauging Equipment, Finished Pistons are Classified into Three Grades for Diameter and Two Grades for Gudgeon Pin Bore Size

Here, Solex gauging equipment is employed for checking the two diameters at each end of the skirt, for which the limits are ±0·01 mm., as mentioned earlier, also the diameter at the top of the larger piston. Caliper gauges are pivoted on a vertical post at the rear, and the set-up shown is for the smaller piston. At this stage, the pistons are sorted into three grades, according to the diameter at a position just below the lower ring groove. Pistons that fall within the range 56·865 to 56·871 mm. are marked with a minus sign, those in the range 56·872 to 56·878 mm. with a capital O, and those in the range 56·879 to 56·885 mm. with a plus sign.

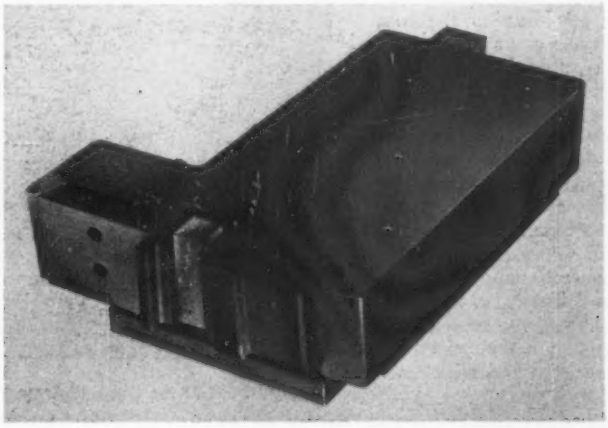
These three sizes correspond to the diameter groups into which the finished cylinders are segregated, as will be explained in a later article. In addition, the gudgeon pin bores are checked with the aid of the Innocenti-made air gauging equipment at the right in Fig. 18, and the pistons are divided into two groups, with bores which range up to 0·003 mm. above, and 0·003 mm. below, the nominal dimension of 16 mm. Those pistons which have gudgeon pin bores larger, and smaller, than the nominal size are marked with white and black paint, respectively, and the gudgeon pins are selectively assembled to provide the desired fit. The pistons also are weighed at this stage to ensure that they are within ±3 grammes of the nominal weight of 146 grammes. Following inspection, the pistons are transferred to the assembly line in special boxes.

Carbide Form-tool Inserts Ground in Gangs

Mechanical holders for solid carbide inserts, as shown in the figure, have been widely adopted for finish-form turning the inner and outer races of tapered roller bearings at the works of the Timken Roller Bearing Co., Canton, Ohio, U.S.A. Inserts for use in these holders can be profile ground in gangs of as many as 16 at a time.

For gang-grinding the profile on 16 inserts, about eight hours is required, as compared with 24 hours when the same number of tool tips was ground separately. The time saved per tip varies from 30 to 60 min., depending on the complexity of the profile.

Only two sets of mechanical holders are needed for each machine. Each insert is held in the holder by a side clamp, and is supported from behind by an adjusting screw. It is a simple matter to substitute a sharp for a dull bit.



This Mechanical Holder is Used on a Single-spindle Automatic. The Carbide Inserts are Employed for Machining Double Cups for Tapered Roller Bearings from Seamless Tubing

A New Spark-machining Technique

By J. D. SHOEMAKER*

At the works of the Lockheed Aircraft Corporation, Burbank, California, U.S.A., spark-machining is extensively employed for finishing the cavities of impact-extrusion dies. These cavities are fairly large and deep, and after the forms have been roughed out by conventional machining methods on die-sinking equipment, the dies are hardened and spark-machined.

The electrodes employed for these operations are made from yellow brass, and the die cavities are first rough machined by the spark process to surface finishes of 140 to 150 micro-inches. Smoother finishes of 80 to 90 micro-inches are then readily obtained. A moderate amount of lapping is subsequently carried out to produce a final finish of 5 to 10 micro-inches. The cavities are held to size within 0·0015 in., and the side surfaces are accurately vertical.

With the conventional arrangement of spark-machining equipment, the work is located in a fibre-glass trough beneath the electrode. A servo-motor feeds the electrode down, so that the correct spark gap is maintained. At the Lockheed works, the original equipment, which was supplied by Elox, was set up on an old horizontal milling machine, as shown in Fig. 1. The trough was mounted on the machine table, and the electrode control-head on the front of the overarm. It may be noted that the milling machine played no part in the operation, serving merely as a unit on which to position the various spark-machining elements. Next to the machine may be seen the power pack, also the coolant pump, reservoir, and filtering unit.

Owing to erosion, the end of the electrode becomes undersize. Consequently, the total length of the electrode, or series of electrodes, employed, must be greater than the height of the die block, and it must be fed for an added distance through the cavity to eliminate any taper on the walls. An important factor in the successful operation of the process is the maintenance of correct pressure and volume of the dielectric coolant. Pressure must be great enough to wash away the particles of metal as fast as they are removed from the work. Depth of coolant in the trough must be sufficient to ensure that the contact area of the electrode and the work is completely submerged. Coolant flow may be directed either through the electrode, if it is tubular (or provided with drilled holes), and out of the gap; or through the cavity, if it has been previously roughed-out, and thence out of the gap. Since most cavities are previously roughed-out, the second arrangement is the most common.

In cross-section, the dimensions of the electrode must be less than those of the cavity, to allow for the gap width. The gap width, in turn, is deter-

Fig. 1. With the Original Arrangement, the Electrode Spindle was Mounted Above the Work as Shown Here

* Lockheed Aircraft Corporation U.S.A.

mined by a number of factors, including the capacity of the power unit, the cutting rate, and the surface finish desired. Data on gap widths have been obtained by experiment, and it is now possible to predetermine accurately the gap width for any given set of factors. Since a gap ordinarily exists completely around the electrode, it is easy to calculate the required cross-sectional dimensions.

Although the equipment initially employed permitted remarkable savings in die-making times, some troubles were experienced. Cavities occasionally showed irregularities, such as waviness, excessive taper, or ridges. It was possible to remove these imperfections by refinishing one wall at a time, with a trimmed electrode so positioned in the cavity that it was clear of all the other walls. Correction in this manner, however, occupied considerable time, so that the purpose of spark-machining was largely defeated.

It was ascertained that, in order to obtain maximum efficiency from the process, the electrode must be supported so that it is unaffected by vibration from adjacent plant, and is not distorted by temperature changes. Consequently, the spindle must be free from play, and rigidly aligned.

A different arrangement for the spark-machining equipment was therefore adopted, as seen in Fig. 2, and the use of the milling machine as a base was abandoned. A new and larger trough was provided, and, instead of being mounted overhead, the electrode spindle was inverted. After a die-block has been positioned in the trough, the spindle is raised through the rough-machined cavity. The electrode is then attached to the end of the spindle, and spark-machining is performed as the spindle feeds downwards.

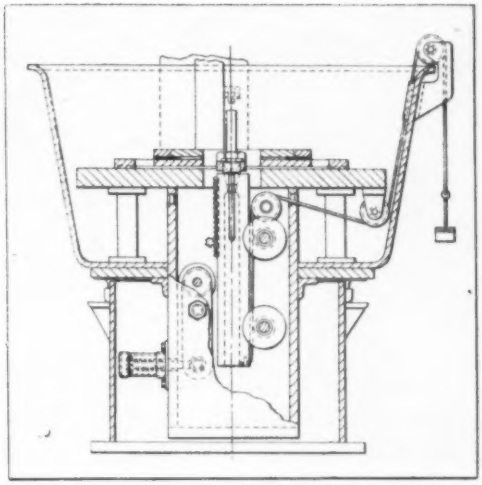


Fig. 3. Cross-sectional View of the Table Showing the Spindle Mounting Arrangements for the Equipment Seen in Fig. 2.

Fig. 2. With the Electrode Spindle Mounted Below the Work Greater Accuracy is Obtained

A cross-sectional drawing of the table and trough is shown in Fig. 3. By confining the spindle in two vee rollers, by means of a flat pressure roller, all clearance is eliminated, and accurate alignment is assured. Better control of dimensions is obtained with this arrangement, and it is unnecessary to realign the electrode in the cavity to compensate for the thermal expansion or contraction which occurred between the milling machine table and the overarm, when the original equipment was in use.

With the new arrangement, continuous arcing between the electrode and the work, without excessive hunting, has enabled the cutting time to be reduced by 50 per cent, as compared with that required on the original machine. Another advantage has been the elimination of ridges or rings in the cavities, believed to be due to excessive hunting of the electrode, variations in power feed control, and inability to adjust the

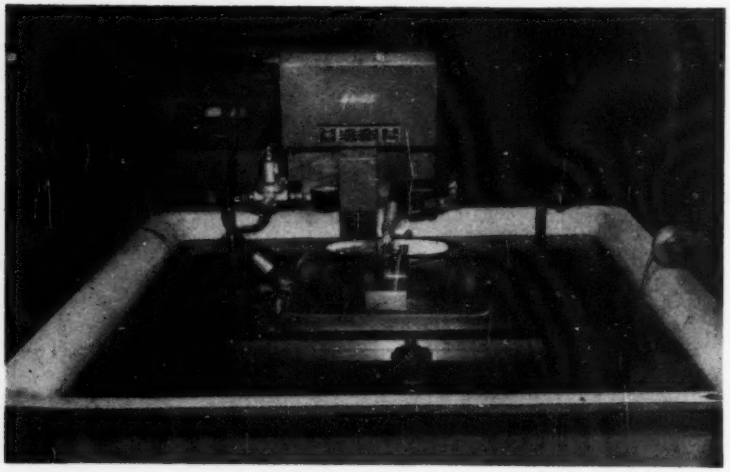


Fig. 4. Close-up View of the Spark-machining Equipment Showing the Plastics Dome, which Encloses the Work and is Connected to a Suction Line for the Electrolyte

coolant flow and direction to the cutting rate.

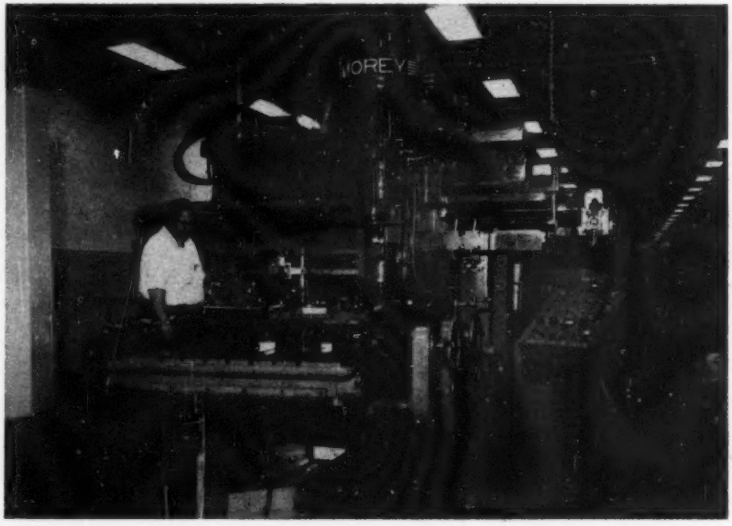
In operation, a plastics bubble, or vacuum dome, is sealed over the work area, as may be seen in Fig. 4. Previous experience had shown that when the coolant flow was opposite in direction to the electrode feed, the best finish and fastest machining speeds were obtained. In the milling machine set-up, this direction of flow was obtained by mounting the work directly over a pressure trap. Coolant was forced into the trap and out through the arcing gap between the electrode and the internal surfaces of the workpiece.

With the new arrangement, the same result is achieved by providing the plastics bubble over the work. Coolant is sucked up through the gap, and recirculated by way of a flexible tube connected to the top of the dome.

MOREY VERTICAL PROFILING AND MILLING MACHINE

To facilitate production of large parts for the U.S. Navy P6M Martin Sea Master multi-jet seaplane, a Morey heavy duty vertical profiling and milling machine has been installed in the works of the Baltimore Division of the Martin Co., U.S.A. Intended for automatic profiling or milling operations on aluminium and steel, this machine employs an electro - hydraulic 3-dimensional tracer.

The 4-ft. by 10-ft. table has a travel of 10 ft. 4 in., and the maximum transverse and vertical movements of the cutter head and spindle, respectively, are 5 ft. and 12 in. Drive is taken from a 40-h.p. motor and the 16 spindle speeds range from 20 to 3,600 r.p.m.



Morey Vertical Profiling Machine at The Martin Co., U.S.A.

Skinner Unit Heads for Transfer Machines

A range of self-contained, motor-driven, unit heads, also sub-slides, bases, indexing work tables and transfer equipment are made by Edward J. Skinner, Ltd., Boulton Road, Lode Lane, Solihull, Warwickshire. From these items, special-purpose machines can readily be built by the user for performing drilling, reaming, tapping and light-duty milling operations on a variety of workpieces for the electrical and light engineering industries. Alternatively, complete machines incorporating these units can be supplied by the company.

Such a machine usually incorporates a central hexagonal bed, which carries the work table and houses electrical equipment, and a number of radially-extending bases for the unit heads. Of compact design, the unit heads may be mounted horizontally, vertically, or in angular positions, and they are available with wide ranges of spindle speeds and feed rates.

Weighing 78 lb., the company's No. 2 unit head, shown in Fig. 1, enables holes up to ½ in. diameter to be drilled in mild steel, and the spindle, which is cam-operated with spring return, has a maximum stroke of 2 in. Drive to the cam is transmitted by worm gearing, an adjustable clutch, and pick-off gears which enable cycle times from 0·76 to 40 sec. to be obtained. A dashpot cylinder is incorporated, which ensures that the spindle is brought slowly to rest at the end of its return stroke, and, at the same time, delivers lubricant under pressure to the feed gears.

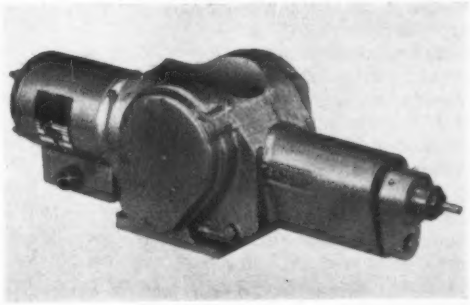


Fig. 1. Skinner No. 2 Motor Driven Drilling Head

Drive may be taken from a motor of ¼ to 1¼ h.p., and the spindle speeds normally range from 750 to 3,000 r.p.m. If required, a gear box and pick-off gears, with the driving motor mounted above or at the rear, may be provided, and spindle speeds from 250 to 3,000 r.p.m. can then be obtained. Other equipment available includes right-angle milling attachments with, and without, an outboard support arrangement. Of hardened steel, the spindle is mounted in angular contact bearings, and the quill moves axially in graphited bronze bearings.

This unit can also be supplied for high-speed tapping duties, with a capacity for cutting screw threads up to $\frac{5}{16}$-in. Whitworth in mild steel. In operation, the driving motor runs continuously, and reversals of the spindle are effected by magnetic clutches and gears. Direct current, at voltages up to 90, is supplied to the clutches through a rectifier and a potentiometer, which allows a stepless variation of the spindle torque that can be transmitted. In this manner, the risk of breakage of taps can be reduced considerably. Spindle speeds ranging

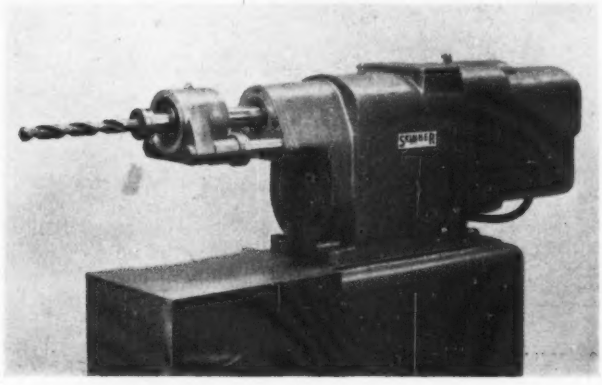


Fig. 2. Skinner No. 3 Drilling Head

from 300 to 1,800 r.p.m. can be obtained by pick-off gears. Axial feed of the spindle, for cutting threads of different pitches, is controlled by pick-off gears, in conjunction with a single cam. When close control of the thread pitch accuracy is required, special cams may be fitted.

The company also makes a complete tapping machine, incorporating this spindle head. As was described in MACHINERY, 90/655—22/3/57, the machine can be arranged for operation on a push-button controlled single-stroke cycle, or for continuous automatic working. The tapping head is mounted on a slide, which has a vertical adjustment of 6 in. on the column ways, and a maximum distance of 10 in. is obtainable between the spindle nose and the work table.

In Fig. 2 is shown the Skinner No. 3 unit head, which has a capacity for drilling holes up to ⅞ in. diameter in mild steel. Drive is taken from a stator-rotor unit, of 1 or 2 h.p., which is housed in the base, and spindle speeds ranging from either 250 to 2,000, or from 500 to 3,000, are provided. The spindle has a maximum stroke of 6 in., the feed motion being by a differential drive and rotating screw. Spindle speeds and feeds are changed by means of pick-off gears, at the rear end of the unit, and cycle times ranging from 3 to 20 sec. can be obtained.

In addition, the company build orbital transfer machines, incorporating a number of bed units, which carry 15-in. square platens to take work-holding fixtures. These units are arranged to form a rectangle, as viewed in plan, and spindle heads are provided at different positions, as required. With this arrangement, machining operations can be performed on three surfaces of the work simultaneously, and as many as five faces can be presented to the cutter heads, during the operating cycle of the machine, without the need for indexing or re-setting the workpiece. A view of a partly-completed transfer machine of this type, for performing operations on an electrical component, is shown in Fig. 3. Indexing and interlocking of the work platens are effected by means of compressed air.

Equipment made by Edward J. Skinner, Ltd., is distributed by an associated company, Stanley Howard, Ltd., 73 Devon Street, Birmingham, 7.

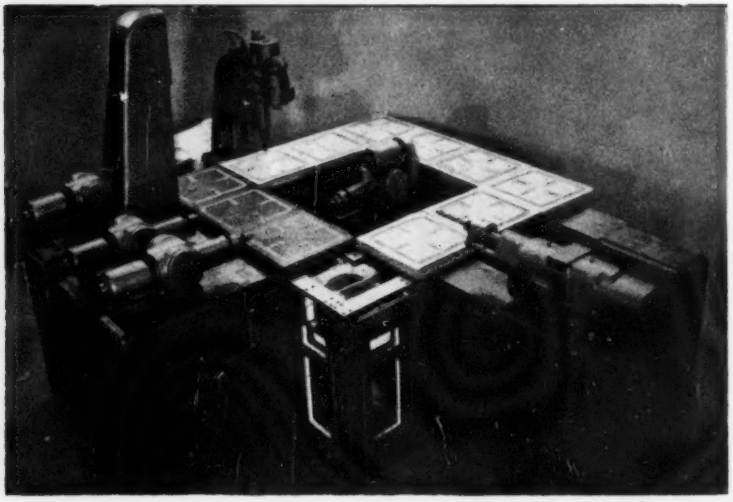


Fig. 3. View of a Partly-completed Orbital Transfer Machine Incorporating Skinner Unit Heads

---

DOWLING ENGRAVING MACHINES WITH ELECTRICAL ETCHING EQUIPMENT.—David Dowling, Ltd., Roebuck Lane, Hainault, Ilford, Essex, have adapted their 848 and 713 bench engraving machines for use as electrical etchers. For this purpose, the machines are equipped with etching heads and transformers made by Martindale Electric Co., Ltd., Westmorland Road, London N.W.9, so that they are suitable for marking such materials as case-hardened steels, hardened alloy steels, and high-speed steels. There are no alterations to either machine as regards manipulation and ratio settings.

For the etching of thin materials, a low tapping is used, and for thick materials, two other tappings are available. Both machines can be supplied for etching, or for both etching and engraving.

The company is also considering the adaptation of machines to incorporate vibratory marking heads, if there appears to be sufficient demand. This development would be undertaken in association with Martindale Electric Co., Ltd., and each machine would be equipped with the head from a Martindale Marker vibratory marking tool.

Equipment for Automatically Coating Washing Machine Tubs with Slip

By J. H. BAUER*

Tubs for home laundry washing machines are produced in large quantities at the works of the Whirlpool-Seeger Corporation, Clyde, Ohio, U.S.A. These tubs, which are fabricated from sheet steel, are washed, pickled, and coated with a high grade of vitreous enamel, inside and outside.

At a first stage in the enamelling process, a base coat of slip must be applied smoothly and uniformly. This slip consists of finely-ground silicious material suspended in water. The coating is applied by dipping, and it is important that runs and sags should be avoided.

For many years, dipping was carried out by hand, and this was a tiring procedure, which not only required skill but was also difficult to control. After they had been hand-dipped, the tubs were hung from an overhead chain, and turned by hand to avoid runs and sags. Unless extreme care was taken, undesirable marks were left by this handling.

To expedite processing, reduce labour requirements, and, at the same time, improve the quality of the base coating, the equipment, here illustrated, has been installed and is in successful use. Each tub is first loaded on a special spider-type carrier, as shown in Fig. 1, and is advanced round a loop track. A portion of the carrier projects through a central hole in the bottom of the tub, and is expanded so that the work is gripped at the hole.

This action is initiated by a cam on the track. In addition, conical points are brought to bear on the underside of the tub bottom, where minor marks in the finish are permissible.

Further along the track, the gear at the inner end of the carrier engages a rack and begins to rotate the tub slowly. This motion continues during dipping, also during the partial drying that takes place before the coated tub is ready for removal from the equipment.

Just after the tub starts to rotate, it dips into the tank containing the slip, which is seen in Fig. 1. Cams along the track cause the tub to be lowered for immersion, raised to pass above the end of the dip tank and, finally, lowered to the inclined position shown in Fig. 2 and 3.

In the inclined position, excess slip drains off all the surfaces, leaving the thin coating desired. Slip is collected, and is returned to the mixing room for re-blending and subsequent use. During the drip period, the tubs are jarred so

* Clyde Division, Whirlpool-Seeger Corporation, U.S.A.

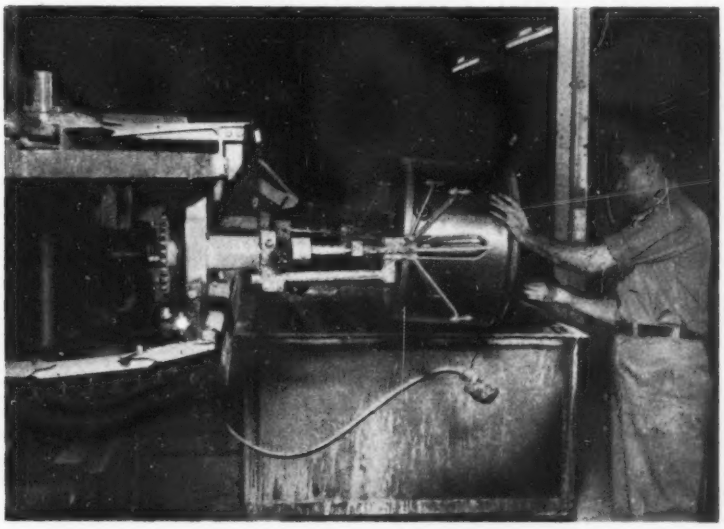


Fig. 1. Washing Machine Tubs are Loaded by Hand on Spiders on a Loop-conveyor. A Gear at the Inner End of Each Carrier Engages a Rack and the Tub is thus Caused to Rotate Until it is Unloaded

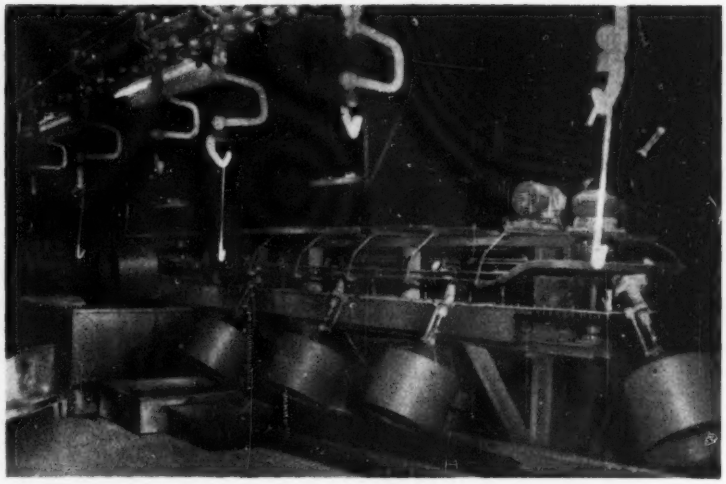


Fig. 2. On Leaving the Tank, the Rotating Tubs are Tilted Downwards so that Excess Slip can Drain Off. Intermittent Shaking Jars Off any Drops that May Form

that any drops of slip formed in draining will fall off and not produce sags. Continued rotation helps to avoid runs, also to minimize variations in coating thickness.

It may be noted that the tubs are not touched by hand after they have been loaded on to the spiders. Hooks used for unloading are passed through small holes in the rim of the tub, where no noticeable blemishes are left. At a station near the end of the second leg of the conveyor loop, the spider is released from the tub, and the latter is then lifted off and hung from a hook on an overhead chain conveyor, with the open side sloping upward, as in Fig. 3.

By this time, however, the slip has dried sufficiently to avoid running on the coated surfaces. On this chain, the tub is carried, first, through a drying oven, and, then, through a continuous firing furnace. In the latter, the dry slip is heated to a temperature sufficiently high to melt and fuse the vitreous particles. When the tubs emerge from the furnace, they have cooled to some extent and are blue-black in colour. After further cooling, a slip of different composition is applied, which is then fired to produce the final white finishing coat of vitreous enamel.

For applying the base coat, with the conveyor equipment here illustrated, only two men are needed—one being engaged in loading, and one in unloading.

When dipping was done by hand, five men were employed. Thus, for the production rate required, labour has been reduced by 60 per cent. In addition, a superior coating is obtained and the need for reworking is reduced.

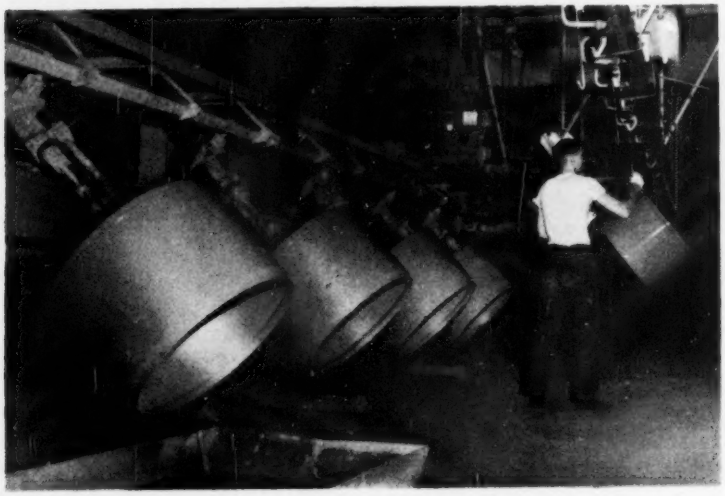


Fig. 3. At the Rear of the Conveyor Loop, the Spider is Unlocked Automatically. A Hook is Used to Transfer the Coated Tub to a Chain Conveyor for Passage Through a Drying Oven and a Firing Furnace

New Production Equipment

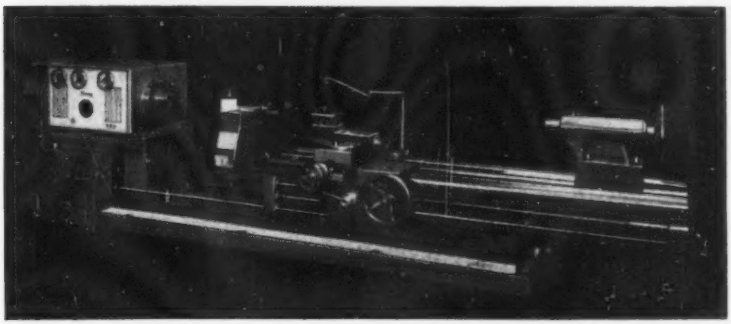
Stanley 12½-in. Centre Sliding-bed Lathe

Stanley Machine Tool Co., Ltd., New Bank, Halifax, have recently redesigned their sliding-bed lathes, of 10½-, 12½- and 14½-in centres, and the 12½-in. centre machine is shown in the accompanying figure, with the sliding bed fully extended. The 21¾-in. wide bed has an overall length of 10 ft., and with the gap closed, 3 ft. 11 in. is admitted between centres, and with the gap open, 6 ft. 5 in. Work up to 18 in. diameter can be swung over the saddle, and up to 52 in. diameter by 30 in. wide with the gap fully open.

Driven by a 15-h.p. motor, the primary shaft in the all-geared headstock runs at 500 r.p.m., and there are 18 spindle speeds ranging from 7 to 375 r.p.m. The spindle is mounted in Timken taper roller bearings at the front, and a plain roller bearing at the rear, and has a bore of 4¾ in. diameter.

A quick-change gearbox, with reverse motion, provides 32 sliding feeds, from 0·064 to 0.0044 in. per spindle rev., for the saddle on the bed, also for the back rest, which is mounted on a short auxiliary bed, and is used for turning the larger diameters swung in the gap. Surfacing feeds are also provided, and range from 0·036 to 0·0026 in. per spindle rev. The feed-shaft is of 1½ in. diameter and is fitted with a safety slipping clutch, and the 2¾-in. diameter leadscrew can be disengaged when not in use. Standard Whitworth threads from 2 to 28 per inch can be cut, also, with extra wheels, a range of metric threads.

Equipment supplied with the machine includes a following steady rest of ¾- to 6-in. capacity; a roller bearing steady rest, with two sets of jaws, to cover a range of diameters from 1 to 18 in.; and a stationary steady rest for workpieces ranging from 1¼ to 11 in. diameter.



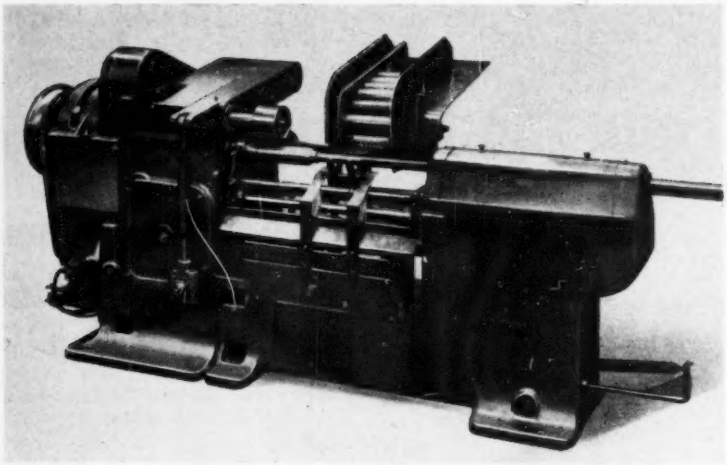
Stanley 12½-in. Centre Sliding-bed Lathe

Moon Trimming and Beading Machine

The machine here shown has recently been introduced by Moon Brothers, Ltd., Beaufort Road, Birkenhead, for performing such operations as trimming, beading, curling, swaging, and thread rolling, on tubes and deep drawn parts, from 1¾- to 6 in. diameter and up to 15½-in. long, with wall thicknesses up to 12 s.w.g.

Trimming is usually carried out separately, but other operations can sometimes be combined. The machine is shown set up for trimming, on an automatic cycle, 3-in. diameter by 10-in. long bodies for fire extinguishers, which are delivered to the loading position by an inclined magazine chute. The latter is adjustable, so that components of different sizes may be accommodated. Alternatively, workpieces may be delivered to the machine by a conveyor.

During the operating cycle, endwise pressure is applied to the com-



Moon Trimming and Beading Machine for Tubular Parts Set-up for Operations on Fire Extinguisher Bodies

ponent by a pusher rod, and the trimming or forming tool, which is carried on a pivoted light-alloy beam at the workhead end of the cast-iron base, is applied by the action of a cam. Upon completion of the operating cycle, the component is automatically discharged from the work holder by an ejector mechanism, which also removes the cut-off piece if trimming has been carried out.

Drive may be transmitted through a flat belt from line shafting, or a 4-h.p. motor, with V-belts and pulleys, can be provided. The workhead spindle, and the spindle for the pusher rod at the right-hand end of the bed, run in phosphor bronze bearings, and are driven through change gears. For the camshaft, the drive is taken through worm gearing, which runs in an oil bath and provides a speed reduction in the ratio of 24 to 1.

Spindle speeds of 600, 720 and 960 r.p.m. are provided, and workpieces can be handled at the rate of 25, 30 or 40 per min. The spindle is bored to accommodate shanks of No. 3 Morse taper.

An adjustable fulcrum piece enables the working stroke of the pusher rod to be varied readily. Shear pins are incorporated in the drive system to avoid damage to the transmission in the event of overloading due to the presentation of faulty workpieces or incorrect loading.

The machine occupies a floor space of 12 ft. 4 in. by 4 ft. 4 in., and weighs approximately 2 tons 6½ cwt.

New Brauer Toggle Clamps

Some recent additions to the range of toggle clamps made by F. Brauer, Ltd., Grove Road, Harpenden, Herts., are shown in the accompanying illustrations. The clamping element of the unit at the left in Fig. 1 takes the form of a plunger which is moved axially, in a bearing fixed to the base, by the action of a trunnion-mounted air cylinder and a toggle mechanism. Known as the type TC1000, this equipment enables a clamping load of about 1 ton to be applied to the work.

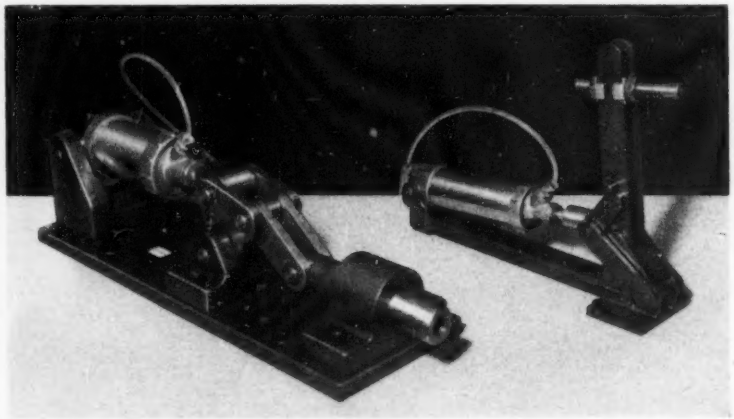


Fig. 1. Two New Brauer Air-operated Toggle Clamps

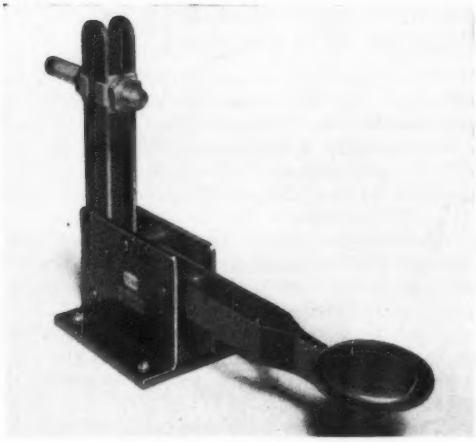


Fig. 2. Brauer Type TC 277 Hand-operated Toggle Clamp

With the type TC800 toggle clamp, seen at the right, which is also operated by a trunnion-mounted air cylinder, downward pressure is applied to the work. The clamping member is a threaded pin, which is adjustable lengthwise to suit the work thicknesses, and may be set at different distances from the pivot axis of its support arm. The design of the toggle mechanism is such that when the clamp is released, this arm is swung through 90 deg. so that it is brought to the vertical position, as shown. A clear space is thus provided in front of the clamp, to permit the workpiece to be lifted vertically for unloading.

If suitable actuating mechanisms are provided for the control valves, both these clamps can be operated automatically, in conjunction with indexing tables and work transfer equipment, for instance.

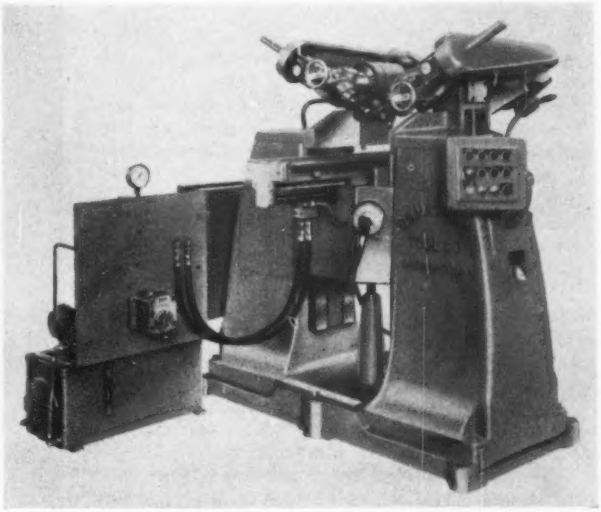
The company's new TC 277 lever-operated toggle clamp is shown in Fig. 2, fitted with an adjustable pin for applying clamping pressure to the work horizontally. Alternatively, an attachment can be provided whereby downward clamping pressure is exerted. A large-diameter mushroom-shaped pad is attached to the end of the operating lever, so that the clamp can be applied conveniently by pressure with the palm of the hand.

Hy-Flex Double-column Hydraulic Milling Machine

The double-column, hydraulically-operated milling machine of unit construction shown in the accompanying illustration, has been built by the U.S. Burke Machine Tool Division, Cincinnati, Ohio, U.S.A.

Basically, the machine consists of a bed, twin-columns, a knee and work-table, and a separate hydraulic supply unit. The columns have machined tops, 12½ in. square, and these provide mounting surfaces for a variety of heads. As illustrated, the machine is provided with independent milling heads, but heads for drilling, grinding, boring or special applications may be fitted to suit the customer's requirements. The milling heads shown have a quill travel of 5½ in., and can be mounted in various positions to suit the operations to be performed. A swivelling movement is also provided, so that the spindles can be tilted above, or below, the horizontal, and a worm drive gives a fine adjustment for setting the angular positions of the spindles independently.

The knee, which has a vertical travel of 15 in., is positioned centrally over the vertical adjusting screw. A maximum work-table travel of 30 in. is obtainable, controlled by adjustable stops, and the feed-rate is steplessly variable. Provision is made for forward and return inching movements. Automatic or semi-automatic work-table cycles, of rapid traverse, feed, return and stop, can be



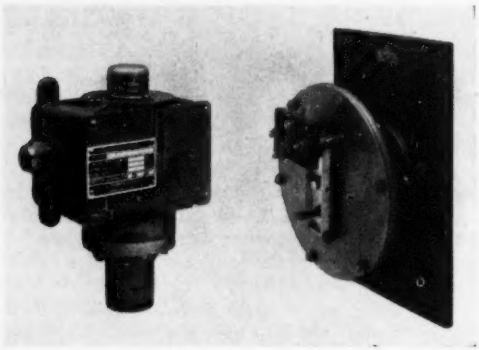
U.S. Burke Double-column Hydraulic Milling Machine

obtained, and the controls are conveniently grouped on a panel adjacent to the operating position.

The machine can be supplied without the heads if required.

Londex Pressure Switches

The two pressure switches here illustrated have recently been added to the range made by Londex, Ltd., 207 Anerley Road, London, S.E.20. On



Londex Pressure Switches

the left side is shown the type PS/P unit, which is designed for use with oil hydraulic systems. It can be supplied in five capacities, with working ranges which can be adjusted from 50 to 250, up to 1,500 to 5,000 lb. per sq. in., for the smallest and largest units respectively. Changes in pressure result in movement of a steel piston, whereby operation of the electrical contacts is effected, and re-setting takes place automatically as the pressure returns to normal. The difference between the "cut-in" and "cut-out" pressures (the re-set differential), ranges from 15 to 50, up to 150 to 300 lb. per sq. in., according to the switch capacity. Each unit has an internally threaded pressure inlet port for a ½-in. diameter pipe.

The type POS switch, on the right, is a low pressure type, and can be used to actuate a vehicle-counting mechanism, or to operate an alarm or an automatic door control unit, for example. It incorporates a diaphragm assembly, fitted with electrical contacts which control a built-in relay energized from a low-voltage transformer, and the maximum switching capacity is 2 amp. at 440 volts A.C. This switch can be supplied to operate over the ranges ½ to 2 in., and 1 to 3 in. w.g., and has a re-set differential of ¼ in. w.g. The pressure-inlet is externally-threaded ¼-in. B.S.P.

Hamilton Triple-action Press for Motor-car Body Stampings

The large, triple-action press, shown in the accompanying illustration, has been built by the Hamilton Division (Hamilton, Ohio) of the Baldwin-Lima-Hamilton Corporation, Philadelphia, Pa., U.S.A., and two of these machines have been installed in the Chicago Heights plant of Ford Motor Co.

Of under-drive design, the machine has a bolster and blank-holder measuring 100 in. by 200 in. The two upper-slides are pulled down by rods, which can extend sufficiently to accommodate blanks of slightly varying thickness without any adjustment of the blank-holder being necessary. The three actions of the press provide for: pulling down the 800-ton blank-holder slide to grip the blank; pulling down the 800-ton inner-slide to make the draw; and pushing up the 550-ton lower slide for a reverse-forming or blanking operation. The speed of operation is nine strokes per min., and the main

Large Triple-action, Hamilton Press for Motor-car Body Stampings

driving motor develops a maximum of 250 h.p.

Speed of stroke is varied, during the cycle, by means of eddy-current clutches and electric brakes, to provide a rapid traverse for approach, and withdrawal, and a slower traverse during the working period. All three slides are mechanically synchronized to maintain the correct relative timing. Lubricating oil is automatically circulated to the slide-operating mechanism, and other parts are served by a centralized greasing system.

All the mechanical, electrical and pneumatic controls are housed within the machine frame, and the slide-operating mechanism is contained in the lower portion of the press, which requires a basement 17 ft. deep.

Expert Transfer Machine for Operations on Motor Car Steering Columns

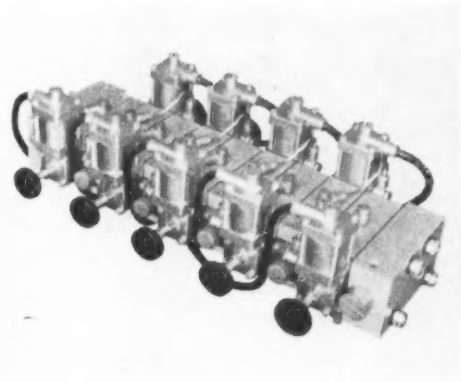
A 7-station transfer machine for part-assembling, welding, machining and testing motor car steering columns has been developed by the Expert Automation Machine Co., Detroit, Michigan, U.S.A., and is shown in the accompanying illustration.

The cycle is initiated by a loading mechanism, which removes the tubes from a hopper and places them on transfer rails, and at the first operation a flange is fitted to one end of each tube. Next the flange is welded in position, and three separate machining operations are then performed on the opposite end of the tube. Finally, the completed assembly is tested, and, if satisfactory, it is stamped and delivered to a conveyor. A production rate of 400 units per hour is obtained.

Since the machine is of unit construction, further operating stations may be added, and adjustments can be made to enable two completely different types of steering column assemblies to be handled. The machine is operated by hydraulic power, delivered from a 30-h.p. unit.

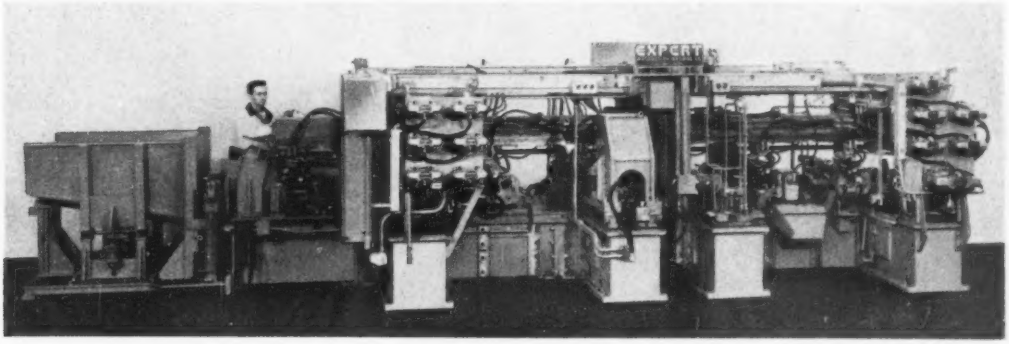
New Baldwin Manifold Valves

The illustration shows an example from the new range of manifold valve assemblies introduced by Baldwin Instrument Co., Ltd., Brooklands Works, Dartford, Kent, for use in compressed air and low-pressure hydraulic systems.



One of the New Baldwin Manifold Valve Assemblies

In this form, up to 12 valves, which may be fitted with manual, mechanical, solenoid or pilot operating mechanisms, can be supplied as a single "packaged" unit. Ports in each valve, for the delivery and discharge of pressure air or fluid,



Expert 7-station In-line Transfer Machine for Part-assembling, Welding, Machining and Testing Motor Car Steering Columns

M

communicate with passages which extend for the entire length of the assembly, so that the need for connecting pipes is obviated. Means for fixing the assembly, and for connecting it to the pipes of the pressure system, are provided in both end pieces.

Of the 4-way type, with ½-in. diameter bores, the valves can be operated independently, and threaded holes are provided in the bodies for the connection of pipes when solenoid-actuated pilot systems are to be employed.

To install the unit, it is only necessary to connect pipes for the supply of pressure air or fluid to one end-piece, and to connect the individual valves to the equipment that they are to operate. When the unit is to be used in a compressed air system, protective hoods are fitted to the discharge ports in the end pieces, also in any solenoid-operated units for controlling the valves. Only a single pipe need be fitted for the return of fluid to a reservoir, when the unit is to be used in a hydraulic circuit.

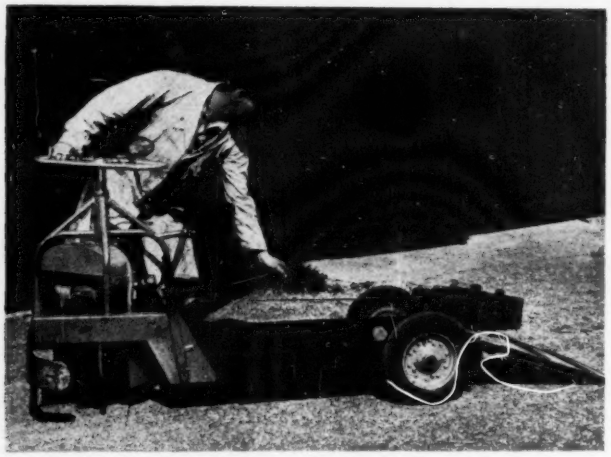
Whades Miniveyor Truck

Whades (Sussex), Ltd., Duke Street, Littlehampton, Sussex, have recently introduced the Miniveyor 3-wheeled truck shown in the illustration. It will carry loads up to 10 cwt., and is powered by a Villiers 2-stroke engine of 147-c.c. capacity.

The engine is mounted in a tubular steel frame over the front wheel, and the drive is transmitted through a centrifugal clutch, chain, and epicyclic gearing. Fitted with a coarse-tread tyre, to provide good adhesion on slippery surfaces and steep gradients, the front wheel can be turned through a full circle, so that the truck can easily be manœuvred in confined spaces, and the direction of travel can be reversed by turning the wheel through 180 deg. Hand- and foot-operated brakes act on the rear wheels.

To facilitate loading heavy parts, a hand-operated winch of the ratchet type can be mounted behind the driver's seat, and used in conjunction with a ramp incorporating rollers, which is fitted to the rear end of the 5-ft. 3-in. by 2-ft. 6-in. platform, as shown. When loading has been completed, the ramp can be set vertically to serve as a tailboard.

The platform, which is supported on a box chassis strengthened by channel-section members, can quickly be replaced by a "tip-up" body, of ½-cu. yd. capacity, for carrying such material as sand. This body incorporates a tailboard, which is automatically locked in the closed position when the floor is horizontal. When the body is tilted, the tailboard is automatically released for dumping the load.



Whades Miniveyor Truck

AMERICAN MACHINE TOOL BUILDERS' PROSPECTS.—At the 56th annual meeting of the National Machine Tool Builders' Association, held in the U.S.A. from October 23 to 25, Mr. J. A. Raterman, president of the Association, pointed out that sales by members of the Association during 1957 had an estimated value of about $516,000,000. Although this figure was less than those to which the industry had become accustomed, it was stressed that during the peacetime years from 1946 to 1950, inclusive, also in 1955 and 1956, the average output of the industry was $434,000,000 annually.

The speaker emphasized that the industry could face the future with confidence, since the age and obsolescence of machine tools now in use indicated that the potential market for replacements was very large indeed; there would be a demand for machine tools for plant expansion projects, which had been delayed, but not abandoned; and there was a high rate of research and product development by the industry.

In connection with research generally, another speaker pointed out that American industry, as a whole, would have spent more on research during 1957 than during any other year previously. Expenditure for 1957 had been $7,000,000,000, and a larger expenditure was anticipated in 1958.

Nickols Automatic Sequence-control Equipment

Articles which appeared in MACHINERY, 87/1007—28/10/55, and 89/1131—16/11/56, described the development of the Nickols system of automatic sequence-control, and its application to capstan lathes arranged for operation by means of air cylinders. This development has now progressed to the point at which a new company has been formed, known as Nickols Automatics, Ltd., 7 Carlisle Road, London, N.W.9, which will carry out the conversion of capstan lathes for fully automatic operation in the customer's works. Conversion, including the supply of all the necessary equipment and the training of a setter in the operation of the converted machine, can be carried out for a fixed sum in a period of not more than two days. At present, such conversions are restricted to those machines of which the company have the widest experience, namely the smaller Ward and Herbert capstan lathes, but users of other machines can be provided with information, advice and equipment should they wish to carry out the conversions themselves. As an example of the application of the equipment, this article will describe the conversion of a Herbert No. 2D machine to fully automatic operation, several of these machines having been so converted already.

MECHANICAL ALTERATIONS

The Nickols system is designed so that a minimum of alteration is required to the machine to convert it to automatic operation. No drastic modifications, such as cutting off portions of the machine, are required, and, if necessary, the equipment can be removed, and the machine restored to its former condition, at any subsequent time. A general view of a converted Herbert No. 2D capstan lathe is given in Fig. 1, and the tall square-section metal cabinet seen on the left at the rear, and the smaller control box on the operator's tool chest, house almost the entire sequence control equipment, so that very little extra space is required for the machine in its automatic form. From this illustration, it may be seen that the handwheel for the operation of the cross-slide, together with the feedscrew and its associated mechanisms, have been removed, and these items are stored ready for re-fitting later, if required. Another view of the machine, showing the rear end of the cross-slide, is given in Fig. 2, and, here, the end surfaces of both the cross-slide and the saddle have been drilled and tapped for the attachment of brackets to carry two 3-in. bore air cylinders, each having a stroke length of 4 in. The rams of these cylinders extend away from the cross-slide, and they are fixed to a vertical steel plate which transmits the thrust from one cylinder to the other. Thus, when air pressure is applied to the ram side of the lower cylin-

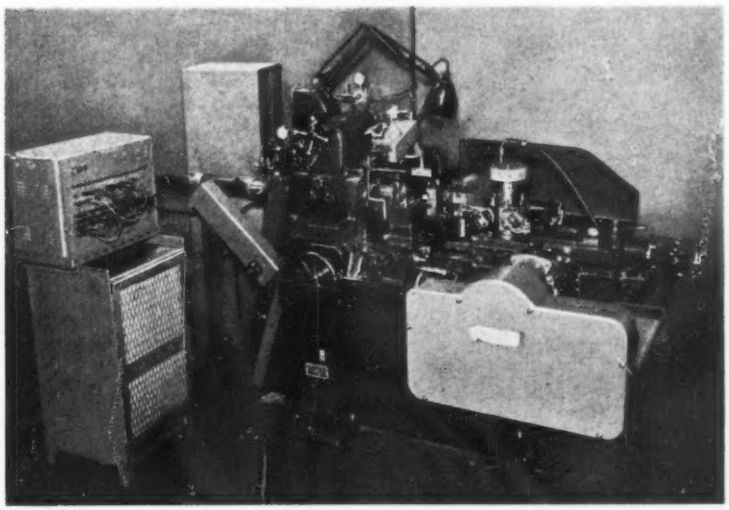


Fig. 1. General View of a Herbert No. 2D Capstan Lathe Converted for Entirely Automatic Operation with the Nickols System of Sequence Control

der, on the saddle casting, the plate is held in a fixed position.

On supplying air to the free side of the piston in the upper cylinder, the cross-slide will then be moved towards the front of the lathe. Conversely, if air is supplied to the ram side of the piston in the upper cylinder, the plate is clamped to the cross-slide, and, then, the admission of air to the free side of the piston in the lower cylinder will cause the cross-slide to move towards the rear. The size of the cylinders, and the air pressure of 80 to 100 lb. per sq. in. employed, ensure that the cross-slide is moved at a fast traverse rate, and the speed is automatically reduced by means of hydraulic check cylinders, one of which is provided for each direction of motion. The piston rods of these check cylinders extend through holes in the vertical plate, and they are threaded for the reception of adjustable nuts which can be locked in any position. When the plate comes into contact with the nut on the appropriate cylinder ram, the speed of the cross-slide is reduced to that permitted by the setting of the adjustable valve of the check cylinder. Steplessly-variable feed rates, up to the maximum speed provided by the air cylinder, can thus be obtained.

The total movement of the cross-slide is limited by the metal box *A*, Fig. 2, attached to the sides of the cylinders. This box is of built-up construction and contains two micro-switches. A threaded bar, attached to a bracket on the cross-slide, passes through the box, and carries two pairs of knurled adjustable collars. When either of these pairs of collars makes contact with its limit switch, a solenoid valve in the control cabinet is operated, to reverse the direction of the air supply to the appropriate cylinder, so that the tool is withdrawn from the work and the next movement of the cycle is initiated, as will be explained. When the air supply is connected to the ram sides of the pistons in both cylinders, the cross-slide occupies the mid-position, as shown.

TURRET MODIFICATIONS

Modifications to the turret-operating mechanisms may be seen in Fig. 2, and in the close-up from the front of the machine, Fig. 3. From these two illustrations, it will be noted that the turret locking handle has been replaced by a short-stroke air cylinder, of 5 in. bore. This cylinder incorporates a number of small coil springs to provide for return motion, and, when air pressure is not acting on top of the ram, the turret is unlocked and can be indexed by the normal mechanism fitted to the machine. The disc carried at the rear end of the capstan slide, in which the dead stops for the turret movements are normally fitted, has been replaced by a larger disc, into which the same stops are screwed. Holes near the outer edge of this larger disc provide for the insertion of six long threaded rods, which are steadied at their outer ends by a drilled annular member. Each rod has a stop collar with rounded edges, which is held in place by a locknut on each side, and, as the turret is fed forward, one of these collars operates a limit switch, by pushing against a roller *B*, Fig. 2, held in the forked end of a lever. Seen at *C* in Fig. 3, this limit switch serves to complete a circuit which results in the engagement of the slow feed motion, as will be explained. The capstan slide dead stop also

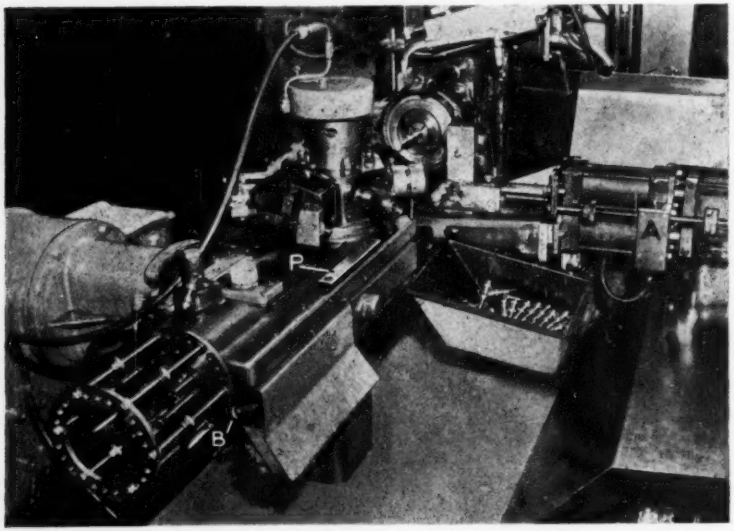


Fig. 2. A View of the Machine from the Rear, Showing the Arrangement for the Operation of the Cross-slide by Two Air Cylinders, and Other Modifications. The Metal Strip *P* Serves to Close the Die Head During the Indexing Movement of the Turret

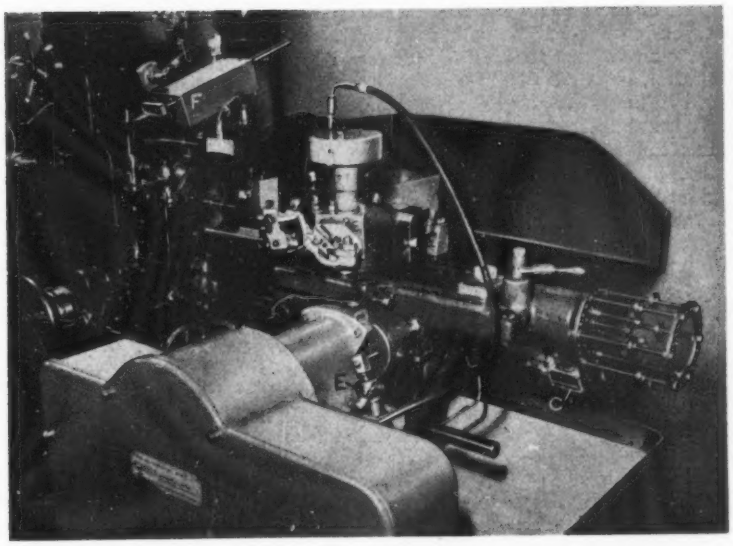


Fig. 3. Close-up Front View of the Automatic Capstan, Showing the Air Cylinder *E* for Engaging the Mechanical Feed of the Machine, and the Microswitch *C* which Controls this Cylinder or, Alternatively, Two Hydraulic Check Cylinders

has been modified, so that it operates a microswitch when the slide is in the advanced position.

In addition to these modifications, the spoked hub, whereby the capstan slide is moved, has been removed from its shaft at the side of the machine, and it is replaced by a pinion, which is housed in the cast aluminium cover seen in the left foreground in Fig. 3. A close-up view of the inside of this cover is given in Fig. 4, and the pinion is housed in the part-circular portion at the top. Beneath the pinion there is a rack, supported on ways attached to brackets on the inside of the cover casting. A substantial bar *D*, secured to the far side of the rack, extends downwards, and is connected to the ram of a 3-in. bore air cylinder, with a stroke length of 8 in., which is carried on the inside vertical face of the cover. When air pressure is admitted, through a solenoid-operated, spring-return valve, to the ram side of the piston in this cylinder, the rack is moved to the right, rotating the pinion and causing the capstan slide to advance towards the work. Reversal of the direction of the air supply to the cylinder, when the current supply to the solenoid valve is cut off, withdraws the slide, and as the bar *D* completes its movement to the left it operates a limit switch within the cover casting, to close a circuit indicating that the capstan slide is fully withdrawn. The bar *D* also has two clearance holes for threaded extensions to the rams of two hydraulic check cylinders, mounted on the inner wall of the cover at the lower

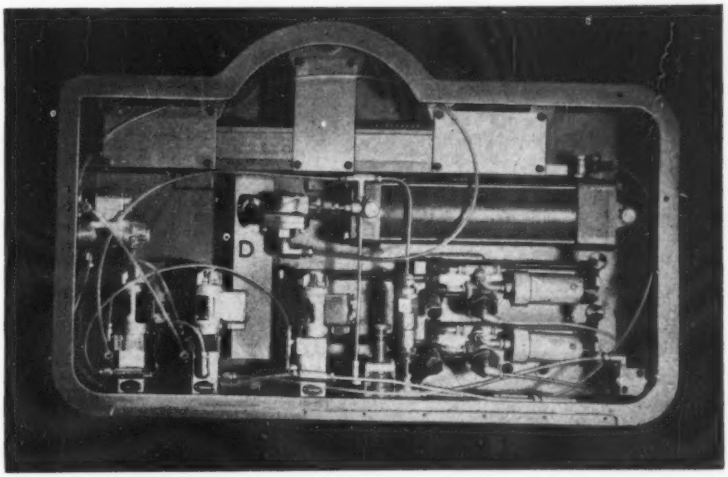


Fig. 4. Forward and Backward Movements are Imparted to the Capstan Slide by the Large Air Cylinder, through a Rack and Pinion. Two Hydraulic Check Cylinders Control the Cutting Feed Rate

right-hand side in Fig. 4. Each of these extensions has a pair of locknuts on each side of the bar *D*, and these nuts are so adjusted that the fast-forward movement of the turret, imparted by the air cylinder, can be reduced to the slow feed required for cutting, as the tools approach the work.

Either of the check cylinders can be brought into action at any required position, to provide two alternative rates of air-operated feed of the capstan slide. An air-operated valve is interposed in a pipe through which oil can flow from one side of the piston to the other, in each check cylinder. By operation of this valve, through a solenoid valve controlled by a micro-switch, or by other means, the by-pass pipe can be closed, and then the oil must flow through an adjustable orifice, and movement of the capstan slide is automatically slowed down. The micro-switch operated by depression of the roller *B*, Fig. 2, can be employed to select either of the check cylinders, as required, or for engaging the mechanical feed motion of the machine, as will be described. Normally, the two check cylinders are set to give different feed rates, and are employed when the mechanical feeds of the machine do not suit the particular operation. For such work as screw-cutting or tapping, the rate of travel of the slide must be adjusted in accordance with the spindle speed and the lead. This adjustment is made, first, by calculating the required feed rate in inches per second—by multiplying the revolutions per second by the pitch—and, then, setting the valve of the check cylinder until the slide moves at that rate. The scale fitted to the slide and a stop watch are employed, and a reading is usually taken over a distance of 2 in. to ensure the necessary accuracy. Threads cut in this way will pass all normal commercial, and most aircraft, standards.

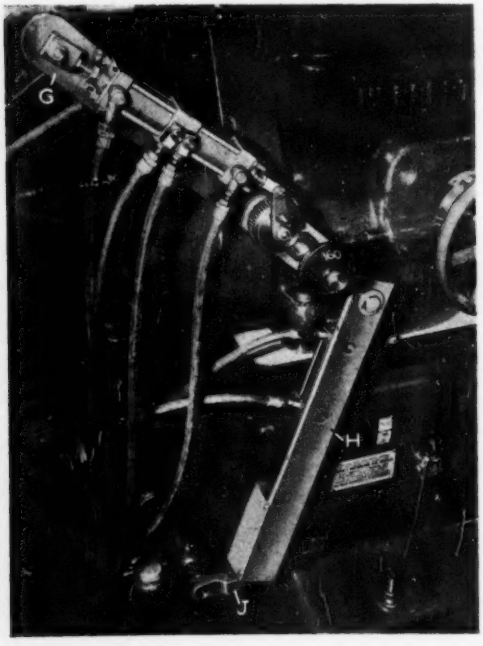


Fig. 5. The Mechanical Feeds of the Machine are Selected by Means of the Two Coupled Air Cylinders on the Plate *G*, which Allow for Three Different Settings. High or Low Spindle Speed Ranges are Engaged by the Cylinder on the Plate *H*

As stated earlier, mechanical feed for the capstan slide can also be brought into operation at any point in the cycle. The lever whereby these feeds are normally engaged, when the machine is hand operated, is connected to the ram of a small single-acting air cylinder *E*, Fig. 3, which is yoke-mounted in a bracket on the side of the aluminium cover. The cylinder shown, unlike the other air cylinders employed for this conversion work, is of a special design, since the return spring, whereby the feed motion is disengaged when the air pressure is cut off, must be on the opposite side to the ram. A standard cylinder of this type is now available, however, and will be employed for all future conversions. Air is supplied to the ram side of the cylinder, when the feed is to be engaged, through a solenoid valve operated by the limit switch *C*, Fig. 3, and the circuit to this switch is automatically closed and opened, as required, by the automatic control equipment. Another air cylinder, of 2½-in. bore, with a stroke length of 6 in., is employed to open and close the collet chuck. Housed beneath the cover *F*, Fig. 3, this cylinder is yoke-mounted in a bracket on the headstock, and its ram is connected to the collet-opening lever of the chuck. Attached to the ram of this cylinder is a plate, which carries a long rod with two stops for operating limit switches. In this way, circuits are completed to show whether the chuck is open or closed.

FEED AND SPEED SELECTION

Normally, three mechanical feeds, of 80, 160 and 320 cuts per in., are available for the capstan slide on the Herbert machine, and any one of these feeds can be engaged by the mechanism seen at the top in Fig. 5. Here, an outrigger plate *G* provides a mounting for two small air cylinders, which are coupled back-to-back. The ram of one of the cylinders is connected to a stud, projecting from the

plate at the upper end, and the ram of the other cylinder to a short lever. This lever is secured to the side of a spur gear, which is mounted on a stub shaft projecting from the face of the plate *G*. The teeth of the gear engage with those of a pinion mounted on the feed-change shaft of the machine. By means of the two cylinders, the feed-change shaft can be turned to any one of three different positions. With both pistons retracted, as shown, the shaft is in the position in which the feed rate of 160 cuts per in. is selected, as shown by the dial. Extension of the ram of one of the cylinders turns the shaft so that the rate of 320 cuts per in. is selected, and extension of both rams selects the rate of 80 cuts per in. The cylinders are normally covered by a guard, as seen at the left in Fig. 1.

On the Herbert lathe, either of two ranges of eight spindle speeds may be chosen during setting, since the drive may be transmitted by flat belt to a high- or low-speed pulley inside the headstock. The speeds to be used are then normally selected by means of a rotary switch on the headstock, which controls a 4-speed driving motor, in conjunction with a 2-speed clutch, which is operated by a lever at the side of the machine, through a linkage. Thus, eight speeds are available to the operator of such a machine, even if they are not all required for the production of a particular component. It is sometimes difficult, however, to ensure that an operator will select the correct speed for each stage, and he may omit to change speed if the difference between those specified for one stage and the next is small, or if a machining stage is of short duration. Since the spindle speeds are selected automatically with the Nickols equipment, it is possible to ensure that the optimum values are employed, so that maximum tool life is obtained. In converting the machine, the switch is disconnected, although the reversing switch lever is left in operation for convenience when setting. The selection of motor speeds is then controlled by solenoid-operated contactors in the cabinet in the left background of Fig. 1.

This cabinet is divided into two compartments by a sheet metal panel, on which the contactors and other equipment are mounted, and a similar—unconnected—cabinet is seen with the cover removed in Fig. 6, where the two views show opposite sides of the panel. The motor is supplied with 400/440-volt, 3-phase, A.C. current by the contactors, the solenoids of which are operated by a 50-volt A.C. supply.

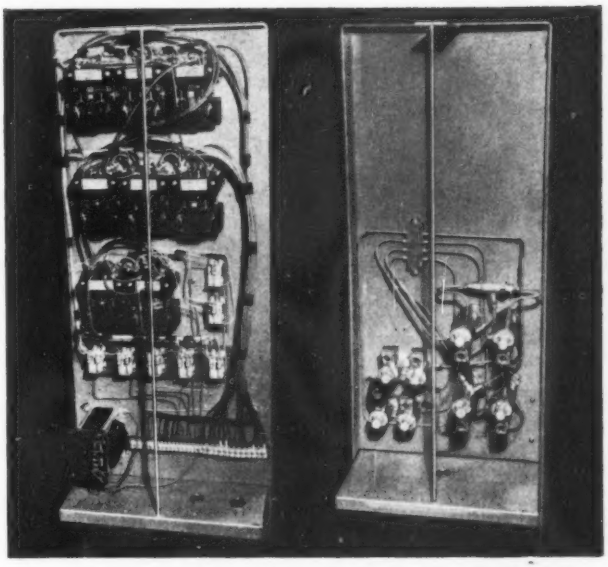


Fig. 6. Views Showing Opposite Sides of the Contactor and Valve Gear Cabinet with the Cover Removed. At the Lower Left may be seen the Transformer which Supplies Low-voltage Current for the Operation of the Control Equipment

On the converted machine, the lever and linkage whereby the change-speed clutch of the machine is normally operated has been removed, and replaced by the steel plate *H*, Fig. 5. To the other side of this plate is fastened another air cylinder, with its ram connected to the lever *J* of the clutch-operating mechanism. By completing circuits to a contactor for the required motor speed, and to a solenoid valve on the panel at the right in Fig. 6, for the correct clutch setting, the specified spindle speed is obtained. This completes the work necessary for the conversion of the lathe to automatic control, and it now remains to describe the automatic sequence control equipment, and the procedure for setting up the machine to produce a particular component.

AUTOMATIC SEQUENCE CONTROL EQUIPMENT

The equipment, whereby the series of movements of the machine elements is controlled, is contained in the small cabinet on the operator's tool locker at the left in Fig. 1. A close-up view of the

front of this cabinet is given in Fig. 7, and it may be noted that the sheet metal front panel is made in two halves, with a horizontal division at the approximate centre. The upper half panel is designed as a standard unit, but the lower half may be varied according to the type of machine which is to be controlled by the unit. On the rear face of the panel there are four studs, which support a standard uni-selector switch with 25 vertical rows, each of four contacts. The contacts are arranged on a semi-circular quadrant, and at the centre of this quadrant there is a double sweep-arm, each end of which is provided with four contacts. This arm can be indexed, so that circuits may be completed with any row of four contacts on the quadrant, by means of a solenoid operating through a ratchet mechanism. At the front of the panel there are 24 vertical rows, each of four single-pin sockets, and the individual sockets in each row are connected to the individual contacts on the switch quadrant. Thus, as the switch arm is moved round the quadrant, each row of sockets on the panel is energized in succession, and is connected, through the switch, to whatever piece of electrical equipment—for example a contactor solenoid—is plugged-in to the individual sockets. Where a machine requiring a large number of functions is to be controlled by the unit, a sheet metal panel with a maximum of eight sockets in each vertical row, and fitted with a uni-selector switch having corresponding numbers of contacts, can be substituted for the standard lower half panel member.

A simple example will explain the operation of the uni-selector switch. Suppose that it is required to open the chuck jaws, advance the bar, and close the jaws again. A connection is made from one of the sockets in the first row to the solenoid valve for controlling the air supply to the chuck-operating cylinder, and another socket in the same row is connected to the micro-switch which is operated at the end of the chuck-opening movement of the cylinder ram. A socket in the second row is connected to the solenoid valve for controlling the chuck-operating cylinder, so that the setting will be reversed when the circuit is energized, and another socket in this row is connected to the micro-switch which is operated at the end of the chuck-closing movement of the cylinder ram. When the switch arm is subsequently indexed—by pressing a button for instance—to start the cycle, a circuit is completed to the solenoid valve which allows air to pass to the cylinder, so that the chuck is opened. The closing of the micro-switch contacts at the end of the chuck-opening movement completes a circuit to the solenoid of the uni-selector switch, so that the arm is indexed to the next position. Here, a circuit is completed to the air-cylinder solenoid, to reverse its setting, so that the chuck is closed, and at the end of the stroke of the cylinder ram another micro-switch is operated. A circuit to the switch solenoid is thus completed, so that the arm is indexed to the next set of contacts, to initiate the next part of the cycle.

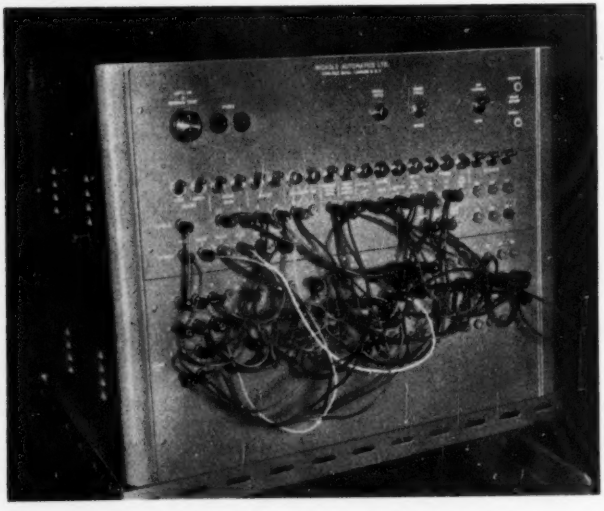


Fig. 7. Close-up of the Control Cabinet for the Nickols System, with Connections Made for the Operational Sequence for Machining a Pillar Bolt

A view of the inside of the control cabinet is given in Fig. 8, where the selector switch is seen at the bottom. The sweep arm is supplied with single-phase A.C. current, at about 110 volts, from a transformer in the cabinet seen in Fig. 6, for the operation of the solenoid valves and contactor switch solenoids of the system. Tappings from the same transformer provide single-phase A.C. current, at about 50 volts, which is passed through a rectifier, in the small cabinet, to give D.C. current for the operation of the solenoid for the uni-selector switch.

On the far side of the plate *K*, in Fig. 8, at the left-hand end, there is a small synchronous electric motor, which runs on a 110-volt A.C. supply, and drives a shaft through a small gearbox at a constant speed of 10 r.p.m. On the end of this shaft is mounted the cam *L*, which is turned

in a clockwise direction. At the lower edge of the plate, there is a micro-switch *M*, the plunger of which is operated through a spring arm with a roller at the end. When the motor is started, it will run until one arm of the cam operates the switch. A circuit is thus completed to the solenoid of the uni-selector switch, so that the arm of the latter is indexed, cutting off the current supply to the motor and initiating the next machine movement. This motor provides a time delay of 3 sec., but by connecting it to the source of current supply, at two or more successive positions of the uni-selector switch, multiples of this period may be obtained if desired. The arrangement serves as a time delay switch, and can be brought into operation at any point in the cycle at which it is desired to hold a machine member in a particular position, for example, to provide a dwell at the end of a forming operation.

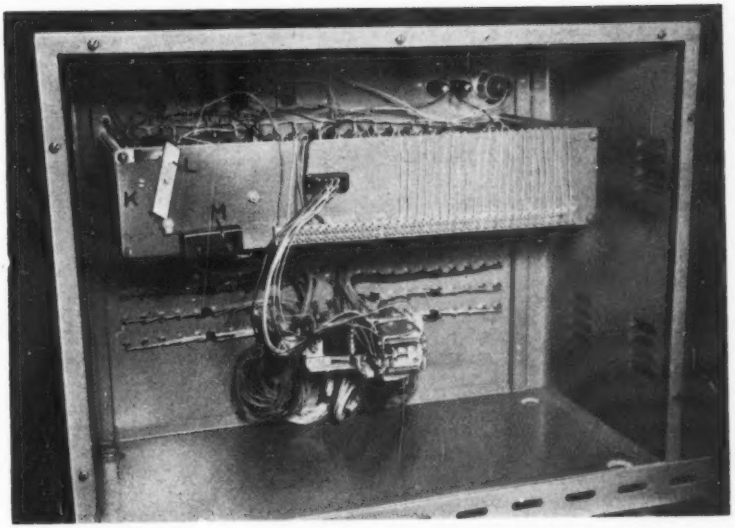


Fig. 8. In this View of the Interior of the Control Cabinet, the Uni-selector Switch May be Seen Below, and the Cam Arm of the Time Delay Unit is Indicated at *L*

Referring, again, to the view of the outside of the cabinet in Fig. 7, the two horizontal rows of sockets on the upper panel are numbered. In addition they are labelled to indicate their functions by brief descriptions, such as "turret forward" or "collet open." Sockets in the upper row, designated "Motions," are mainly concerned with movements of the machine elements, also with spindle speeds and feed rates, and they are permanently connected to the solenoids of the valves for controlling the air cylinders, and to the contactor solenoids. Sockets in the lower horizontal row at the left, designated "Signals," are all connected to the micro-switches on the machine, and are energized when one of these switches is operated. The vertical rows of sockets on the lower panel are numbered from 1 to 24, and the socket in the second position from the top in each row, designated "Index," is connected to a relay, which supplies current to the solenoid of the uni-selector switch. Thus, if one of the sockets in the signal row is connected by a lead to one of the index sockets, the switch will be indexed automatically, as soon as the micro-switch connected to the signal socket is operated, at the end of the movement of one of the machine members. To ensure that the machine will operate in the desired sequence, it is only necessary to connect the sockets for the solenoids and the micro-switches to the appropriate sockets energized by the uni-selector switch, and to start the cycle which then continues automatically.

PRODUCING A PILLAR BOLT

A drawing showing a typical capstan part, known as a pillar bolt, which is produced with the set-up shown in the illustrations so far discussed, is seen in Fig. 9. Made from free-cutting mild steel bar of ⅞ in. diameter, this bolt has a necked portion, which is produced by plunge-forming with a tool mounted in an inverted position on the rear of the cross-slide, the parting tool being at the front of the slide. The turret tools provide for feeding to a stop; turning the end with a roller-box tool for a distance of ¾ in. to a diameter of 0·0383 in. for subsequent threading, ⅜-in. B.S.P.; chamfering the end; turning the 0·454-in. diameter for a length of ⅞ in., with another roller box tool; centre-drilling the end; and cutting the thread with a Coventry self-opening die-head. These operations are completed in a cycle time of 65 sec., which compares quite well with that required on an automatic screw machine. The setting of the tools

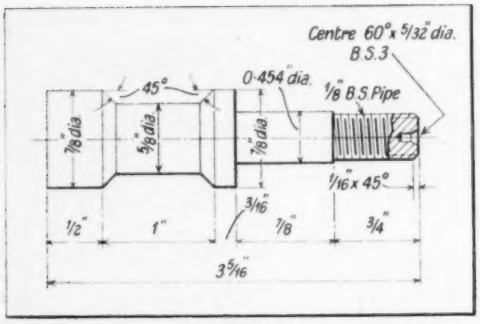


Fig. 9. Details of a Pillar Bolt Produced with a Typical Set-up on the Automatic Capstan Lathe in a Cycle Time of 65 sec.

on the capstan lathe is completed in a period of about 2½ hours, by the conventional cut and try methods, and a further period of about 10 min. is required for connecting the various sockets in order to obtain the desired sequence of operations.

In connecting the sockets, reference is made to a chart prepared by the planning department, a typical example showing the connections for the production of the pillar bolt being shown in Fig. 10. On this chart, brief details of the component are given at the top, to assist identification, and, beneath this heading, there are vertical columns for the insertion of numbers relating to the sockets on the control cabinet. The column headed "Step No." refers to the vertical rows of sockets on the lower panel, and there are numbers from 1 to 24, in accordance with the panel marking. On the lower panel, the horizontal rows of sockets are numbered from 1 to 4, and these sockets are represented by the next four columns on the chart. The upper horizontal row is normally employed for slide movements ("motions"), the next row for signals, as mentioned earlier, and the other two rows for such functions as the selection and engagement of speeds and feeds at the correct points in the cycle. These speeds and feeds are indicated in the next two columns in the chart, and the final column gives a brief description of the operations which result from the connections shown.

To connect the sockets, wires provided with various numbers of plugs are employed. For instance, during a normal machine cycle, for which all six turret faces are to be used, the capstan slide requires to be advanced to its stop six times, and it must be held in the forward position during the opening and closing of the collet. The "motion" socket for the advance of the capstan slide must, therefore, be connected to eight of the vertical rows of sockets on the lower panel, and these connections are indicated by the figure 1 in the column headed "Bank 1, Motions," in Fig. 10, the positions being found by reference to the "Step No." column at the left. The uni-selector switch is indexed to the initial position by a push-button, connected to the relay for the switch solenoid, when the cycle is to be started. The operations controlled by the first position of the switch include advancing the turret to its stop, and starting the spindle drive motor. The connection from the "turret forward" socket in the "motions" row to the upper socket of the first vertical row on the lower panel brings the turret forward, and the connection of socket No. 19 in the "motions" row to one of the other sockets in the first vertical row on the lower panel energizes the solenoid of a contactor switch, so that the motor is started at the slow speed. The "turret forward" socket in the "signals" row is connected to the first of the row of sockets reserved for "signals" on the lower panel, this connection being indicated by the number 2 in the column headed "Bank 2 Signals" on the chart. As soon as the capstan slide reaches the forward position it operates the micro-switch of the capstan slide stop, completing a circuit to the selector switch relay, so that the switch is indexed and the second vertical row of contacts is energized.

Since the "turret forward" socket is connected to one of the sockets in this second row, the capstan slide is maintained in the forward position. At the same time, current is supplied through the connection marked 8 in Bank 3 of the chart to the collet-open socket of the "motions" row, and energizes the solenoid valve controlling the collet-operating cylinder so that the chuck is opened. The machine illustrated is fitted with the Puckert (Dowding & Doll, Ltd.) air-operated bar feed, which enables bars up to 30-ft. long to be fully used, and, as soon as the collet is opened, the bar is automatically fed to the turret stop. Another connection, from the Bank 4 position in this row, is made to socket No. 16 of the "motions" row, which is connected to the solenoid valve of the air cylinder for operating the high- and low-speed clutches of the machine, with the result that the high speed is engaged to provide a spindle speed of 850 r.p.m. All these changes are completed during the movement of the collet-opening cylinder, and when this movement has been completed, the micro-switch connected to socket No. 9 of the "motions" row is operated, so that the uni-selector switch is indexed to energize the third vertical row of sockets on the lower panel. The turret is still maintained in the forward position at this stage, and socket No. 10 of the "motions" row is connected to reverse the setting of the solenoid valve for controlling the collet-operating cylinder,

NICHOLS AUTOMATIC SEQUENCE CONTROL:							SETTING CHART.
MACHINE: 2D HERBERT CAPSTAN.							
PART NAME: PILLAR BOLT.							PART NO: A.117.
MATERIAL: B.M.S. (En.1A) 7/8in. dia.							
STEP NO.	BANK 1 MOTIONS	BANK 2 SIGNALS	BANK 3	BANK 4	SPINDLE R.P.M.	FEED.	OPERATIONS.
1	1	2	19	-	-	-	Feed turret to stop. Start motor.
2	1	9	8	16	850	-	Hold turret forward. Open collet. Engage fast spindle clutch.
3	1	11	10	12	"	(160)	Hold turret forward. Close collet. Set mechanical feed rate.
4	-	3	-	-	"	-	Return turret and index.
5	1	2	14	-	"	160	Feed turret. Engage mechanical feed. Turn 0.383-in. dia.
6	-	3	-	-	"	-	Return turret and index.
7	1	2	-	-	"	Check Cylinder	Feed turret. Engage h/check feed. Chamfer.
8	-	3	-	-	"	-	Return turret and index.
9	1	2	14	-	"	160	Feed turret. Engage mechanical feed. Turn 0.452-in. dia.
10	-	3	21	-	1700	-	Return turret and index. Change motor speed.
11	1	2	-	-	"	Check Cylinder	Feed turret. Engage h/check feed. Centre drill.
12	-	3	19	17	160	-	Return turret and index. Change motor speed. Engage slow spindle clutch.
13	1	2	15	-	"	Threading Check Cylinder	Feed turret. Engage second h/check feed. Screw (self-opening die-head). Open die-head.
14	6	5	16	-	850	Check Cylinder	Return turret and index. Engage fast spindle clutch. Feed rear cross slide tool. Form 5/8-in. dia.
15	6	7	-	-	"	Check Cylinder	Continue feeding rear cross slide tool to depth.
16	6	T/Delay	-	-	"	-	Feed rear cross slide tool to dwell on dead stop. (3 sec. time delay).
17	4	5	-	-	"	Check Cylinder	Retract rear cross slide tool and advance front tool to depth, parting off work piece.
18	-	Home	18	-	-	-	Home. Stop motor.
19	-	Home	-	-	-	-	Home.
20	-	Home	-	-	-	-	Home.
21	-	Home	-	-	-	-	Home.
22	-	Home	-	-	-	-	Home.
23	-	Home	-	-	-	-	Home.
24	-	Home	-	-	-	-	Home.

Fig. 10. Chart Giving Details of the Connections to be Made on the Panel of the Control Cabinet in Fig. 7, for the Production of the Pillar Bolt. The Connections between the Various Sockets can be Completed in about 10 min. by any Competent Tool Setter after a Short Period of Training

so that the collet is closed. Socket No. 12 of the "motions" row is connected to this third row, so that the solenoid valve controlling one of the cylinders for the mechanical feeds (Fig. 5), is energized, and the feed rate of 160 cuts per in. is selected.

The remaining stages in the automatic cycle are controlled in a similar manner. If the mechanical feeds are not required for a particular operation, the upper check cylinder in the aluminium cover is normally brought into operation by the micro-switch *C*, Fig. 3, as the turret moves forward. Should it be necessary to utilize the lower check cylinder for a threading operation, the air supply is diverted to the valve controlling this cylinder. Alternatively, if mechanical feed is to be employed, air is automatically directed to the ram side of the engagement cylinder *E*, Fig. 3.

For closing the chasers of the self-opening die-head, employed for the threading operation, a strip of hardened steel is screwed to the edge of the capstan slide, as may be seen at *P* in Fig. 2. As the die-head passes over this strip, the downwardly-projecting operating lever is moved to close the chasers. At the end of the threading operation, the die-head opens and the capstan slide is returned by its cylinder.

The cross-slide tool employed for the forming operation is fed, under the control of one of the check cylinders, at the rate of 0·002 in. per rev., and, when it has reached full depth, it is caused to dwell for 3 sec. This dwell is obtained by means of a connection from a socket marked "Delay" on the cabinet, to Step 16 of signals Bank 2, so that instead of the tool being withdrawn on the reception of a signal from the micro-switch A, Fig. 2, the time-delay motor in the cabinet is started, and allowed to run for 3 sec. Normally, tools which are fed in this manner will hold a diameter to limits as close as the particular machine will permit. Where great accuracy is not required, and the time delay is not used, the micro-switches for reversing the direction of the cross-slide movement ensure that the tool is fed to the same position during each cycle within limits of ±0·003 in. Similar

limits are obtained with the tools which are mounted in the turret.

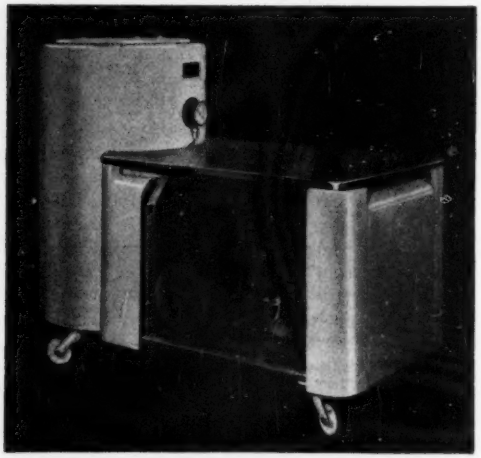
There are 25 vertical rows of contacts on the switch, but only 24 rows of sockets in the panel, so that on reaching the 24th row the arm stops until it is caused to make an additional indexing movement, to start the next cycle, by the operator pressing a button, or by movement of a control switch from the hand to the automatic position. Among the various sockets provided in the panel, there is one for stopping the machine, and lighting a warning lamp, at any point in the cycle at which it may be necessary to carry out some hand work on the component. Having performed this work, the operator presses a button, and the automatic cycle is then resumed.

For setting purposes, control gear housed in the cabinet may be switched to hand operation, so that the row of switches and push buttons at the top of the cabinet can be employed to ascertain that each machine element is functioning correctly. Single cycle operation may also be switch-selected, for chucking work.

The Nickols sequence-control equipment and actuating mechanisms described in this article form the subjects of a number of British patent applications.

Low Temperature Refrigeration Unit

The low temperature unit shown in the accompanying illustration is one of the many types of refrigeration equipment made by J. & E. Hall, Ltd., Dartford, Kent, who have specialized for many years in the design and manufacture of such plant, in addition to lifts. This unit has an internal chamber measuring 20 in. diameter by 36 in. deep, which is surrounded by Santocel expanded silica insulation.



Hall Refrigeration Unit for Temperatures Down to − 150 deg. F.

Under thermostatic control, the cold zone may be maintained at any desired temperature from normal down to −150 deg. F., by means of two coupled refrigeration units, arranged to operate in cascade. The refrigerant in the low-temperature stage of the system can be either Ethane or Freon 13 (Arcton 3), and Freon 22 (Arcton 4) may be employed in the second stage.

Each refrigeration unit is driven by a ¾-h.p. electric motor, and is fitted with an electrically-operated expansion valve to control the flow of refrigerant to the cooling coil. The complete refrigeration assembly is mounted on a wheeled base, to ensure mobility.

Units of this type are in use in the United Kingdom and Europe for various purposes, including the shrinking of metal parts to facilitate assembly, low temperature stabilization of steel, and cyclic testing of materials to ascertain the effects of wide variations of temperature. Apart from the standard unit illustrated, others of different dimensions, to suit special requirements, can be designed and made to order.

THE MILLIONTH OF AN INCH.—In view of the increasingly fine limits now being specified, not only for working and reference gauges, but also for certain workpieces, confusion and mistakes are apt to arise by reason of the large number of noughts which must be written after the decimal point when specifying the limit. Dr. J. C. Evans of the National Physical Laboratory has suggested that the difficulty can be met by the general adoption of the term "microinch" for one millionth of an inch. This term, it may be noted, is already in common use for expressing the values of surface finish, but it is seldom applied in connection with dimensional sizes or limits. The recognized abbreviation for microinch is μin., the Greek symbol μ standing for "micro," *i.e.*, a millionth part.

If the suggested term of microinch were adopted the millionth of an inch would be 1 μin. instead of 0·000001 in., one hundred thousandth would be expressed as 10 μin. instead of 0·00001 in., and 0·000057 in. would be simply 57 μin. There can be no question that Dr. Evans' proposal leads to a definite simplification. Would there be any difficulty in adopting it?

(The views of readers of MACHINERY on this matter would be welcomed.—ED.)

Aircraft Manufacturing Practice—A Review of the British Industry*

By L. G. BURNARD†

The first part of this paper, an abstract of which appeared in MACHINERY, 92/37—3/1/58, was concerned with the machining of integral aircraft components, milling wing skins, machining high tensile steels, and programmed control of machine tools.

PIPE BENDING OPERATIONS

The numbers of pipes required for aircraft have increased enormously, and the load on the coppersmiths' sections has made it necessary to adopt mechanical methods of pipe bending. To permit mechanical bending, it is necessary that every bend in a pipe should be of a true radius, also radii must be standardized, and the necessary bend blocks provided. If these stipulations are observed, it is possible to machine bend almost every pipe required for production aircraft. There are, of course, positions in an aircraft, and piping requirements, which make it necessary to employ non-standard bends, but these are few in number and can be handled by normal coppersmithing methods.

Many different types of standard pipe benders are used in the aircraft industry, including the Pines, the Parker, the Hilger, and special machines developed by aircraft firms for their own use. There have been various developments in connection with machine bending. Fig. 1 shows a small bender for operations on pipes up to $\frac{7}{8}$ in. diameter. On this machine, there is a floating travelling carriage which moves along the bed. A chuck, in which the pipe is gripped, is mounted on the carriage. This chuck can be turned in order to provide for bends in different planes. At the back of the chuck, there is a dial marked in degrees to facilitate setting. A series of angularly-adjustable stops is mounted on the spindle that carries the chuck. Secured to the body of the carriage, is a series of latches, which can be brought into action, one by one, to limit the movements of the angle stops. Settings can thus be made for bends at various angles, and the latches are brought down, in sequence, as each bend is produced, the stops controlling the positions to which the tube is turned.

Extending along the bed of the machine is a bar with a number of stops, which can be adjusted according to the distances between the bends in the pipe. These stops are set in conjunction with a scale on the bed of the machine. At the end of the bed there is a spindle on which the various bend blocks are mounted. This spindle has an operating lever at the lower end, and is connected by means of a chain to a vertical stop assembly, similar to that described in connection with the moving carriage. The stops can be set so that they limit the angle through which the pipe is bent at any specific position.

In operation, the pipe is gripped in the chuck, the carriage is moved to the first longitudinal position, and the spindle is rotated until the first angle-stop engages the first latch. The operator then turns the bending lever until movement is arrested

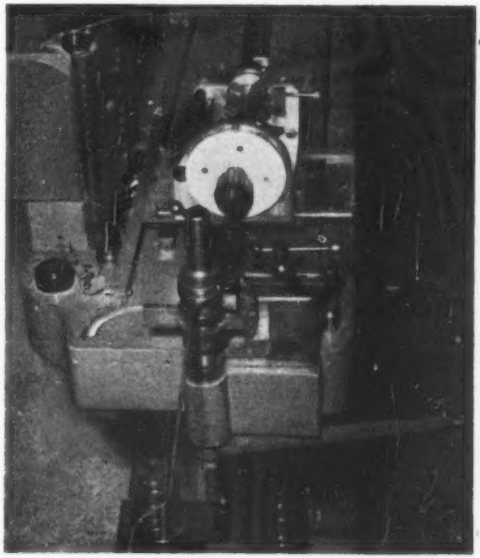


Fig. 1. Bending Machine for Small Diameter Pipes. [Vickers-Armstrongs (Aircraft), Ltd.]

* Abstract of the second part of a paper presented at the Conference on Problems of Aircraft Production organized by the Southampton Section of the Institution of Production Engineers.

† Assistant to the General Manager, Vickers-Armstrongs Aircraft, Ltd., Swindon.

by contact of a vertical stop with the associated latch. A slipper ensures that the pipe is bent, without distortion, around the bend block, through the required angle. When one bend has been completed, the carriage is pulled forward to the next stop. The chuck spindle is then turned so that the plane of bend is determined by the second angle-stop, another vertical latch is advanced to control the amount of bend, and the second operation is carried out. By advancing the carriage along the series of stops on the bed in this manner, and bringing the angular stops into use in turn, it is possible to manipulate any pipe, from ¾ in. to ⅞ in. diameter, into any configuration, by hand. The pipes so produced are very accurately formed, and are readily fitted to the jig boards. Normal pipes can be processed at the rate of about one per min.

When a new pipe is received, it is analysed numerically, and the figures are translated into machine settings. Some slight adjustments may be necessary to provide for springback. As soon as these adjustments have yielded a satisfactory pipe, the stop positions are recorded, and thereafter this record is employed for re-setting the machine.

Wooden jig boards are employed for a similar method. The operator applies a bend block and lever to the jig board in specified positions in a pre-set sequence. A slipper, operated by the bending lever, pulls the pipe around the block, and the edge of a plate, set on the jig board, which indicates the amount of bend, is sighted by eye. The jig boards are made so that a pipe is formed at a series of bending positions, at each of which it is located by the bend which was previously made.

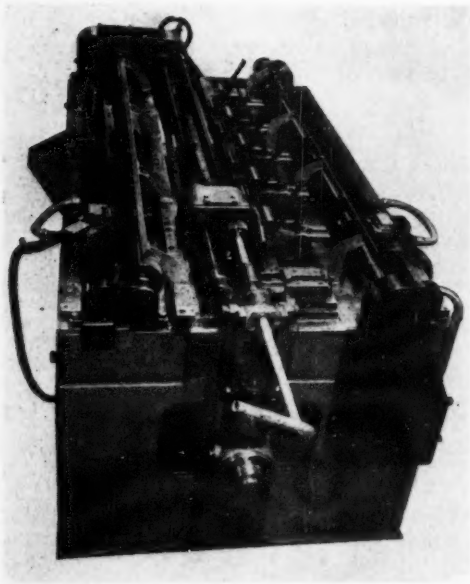


Fig. 2. Extrusion Type Automatic Pipe Bending Machine. [Vickers-Armstrongs (Aircraft), Ltd.]

A machine which is under development will extrude a pipe through a die, to the required form. This machine is illustrated in Fig. 2. The pipe is gripped in a collet mounted on a carriage which moves along the bed of the machine, the drive being provided by a 3-h.p. motor, through a leadscrew. In operation, the pipe is passed first through a fixed die, and then through a movable die. If the movable die is displaced in relation to the other, the pipe will emerge with a bend, and the greater the displacement, the smaller will be the bend radius.

Amount of bend is controlled by means of a countershaft, with a series of cams which can be set to any desired positions. This countershaft is driven by a ¾-h.p. motor, which also provides for the die movement. As the main carriage is advanced along the lead screw, a second carriage, mounting a probe and micro-switch, moves along the countershaft. When the probe engages one of the rotary cams, the micro-switch is closed, the motor is started, and die movement takes place. There are slots in the cams, and when a cam has rotated through the required angle, the probe drops into the slot, and the current to the operating motor for the moving die is switched off. As the probe makes contact, successively, with cams mounted along the countershaft, the die is caused to move up and down, thus producing the bends in sequence.

A second countershaft and carriage system, similar to that just described, turns the collet in which the pipe is gripped, in order to control the angular relationship between the bending planes. With this machine, there are still a few problems to be overcome with regard to repeatability. Small differences in the diameter and hardness of pipes result in slight discrepancies, but adjustments can be made quite easily by hand.

It is intended to eliminate the use of cams, and to substitute electronic control by means of punched tape. It will be evident that, since the pipe can be described numerically, a counting system can be employed to control the movements of the die and the rotation of the collet. In order to set up the machine, it will then only be necessary to introduce the punched paper tape, and fit dies and a holding

collet of the required diameter.

Until recently, pipes were being flared by hand, and beaded by means of bench jennies. A pipe-flaring machine is now employed, which operates by rolling an eccentric punch into the pipe, which is caused to flow into a fixed die. Another machine, which has been developed for beading pipes, has a roller of controlled eccentricity whereby the bead is rolled into a pair of dies. The roller is returned to the central position for loading the pipe, and progressively advanced to the eccentric position, for rolling the bead, by means of a brake applied at the back of the machine. This brake operates through a differential shaft and cross head, to produce the movement of the roller.

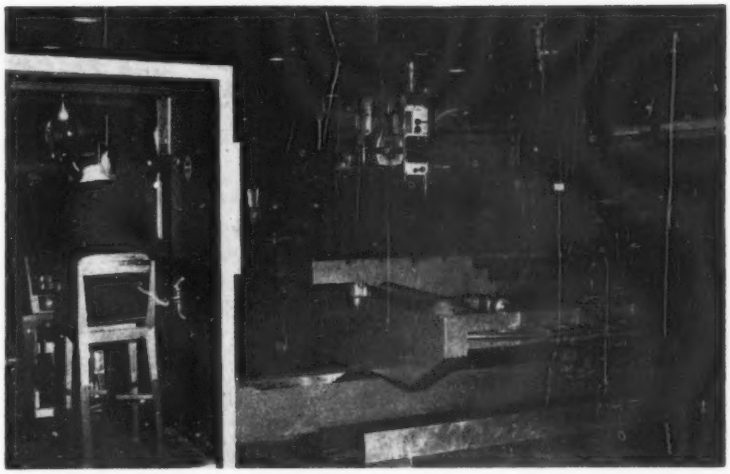


Fig. 3. On this Machine, the Form of a Soft Plate on One Half of the Table is Reproduced on a Template Sheet Carried on the Other Half. [Vickers-Armstrongs (Aircraft), Ltd.]

TEMPLATE PRODUCTION

For routing and copy milling, considerable numbers of profile templates of both large and small sizes are required. In general, the profiles of these templates are determined by lofting methods, either lithographically or photographically. In other words, there is no necessity, as a rule, to lay out the templates from ordinates, since the form can be transferred directly from a loft plate.

To enable templates to be produced quickly and cheaply, a template-making machine has been developed, as shown in Fig. 3. The table of the machine measures 8 ft. by 8 ft., so that it will accommodate an 8-ft. by 4-ft. standard loft plate, and an 8-ft. by 4-ft. template. Longer templates can be handled by indexing the loft plate and the template along the table. The table is mounted on a double slideway system, with 1-in. diameter roller chains, to reduce friction to the minimum. Transverse and longitudinal traverses are obtained by means of two hydraulic jacks, the pressure oil being supplied to the jacks through a 4-way vertical hydraulic valve system. A steering wheel controls the movement of a swash plate which depresses the valves in turn, so that the table can be steered in any direction. The swash plate is connected to an accelerator pedal, and when the deflection of the plate is increased, more oil is allowed to pass through the valves, and the table is traversed at a higher speed.

A loft plate is mounted on one half of the table, beneath an optical unit. By means of a lens system and a series of mirrors, an image of the loft plate is projected on a screen measuring 20 in. by 20 in., which is contained in an operator's cabin. The template to be cut is carried on the other half of the table, over which is mounted a cutting head with a 5-h.p. drive, and spindle speeds from 187 to 6,000 r.p.m. This head can, therefore, be used for milling light alloy or steel, or for drilling operations.

Magnification of the image is 10×, and a disc of ten times the cutter diameter is mounted on the centre of the screen. The operator sits in the cabin, and steers the table so that the image of the line on the loft plate is presented tangentially to the periphery of the disc mounted on the screen. The path traced out by the table as it is caused to follow the line drawn on the loft plate is reproduced by the cutter, and the required template form is thus obtained.

Templates produced in this manner need only light draw filing and dressing of the edges to remove burrs and slight cutter marks.

Titanium is being introduced into British aircraft designs at an increasing rate. So far, it has

been used mainly to replace stainless steel, where heat-resistant and corrosion-resistant properties are necessary. Applications have included, for example, engine bay and jet pipe aperture linings, gun blast tubes, ammunition boxes, louvres, fairings for jet exits hydraulic header tanks, flameproof bulkheads, and hot-air pipes. It follows that considerable quantities of titanium are being formed, cut, and welded. No difficulty has been experienced in forming commercially - pure grades of titanium.

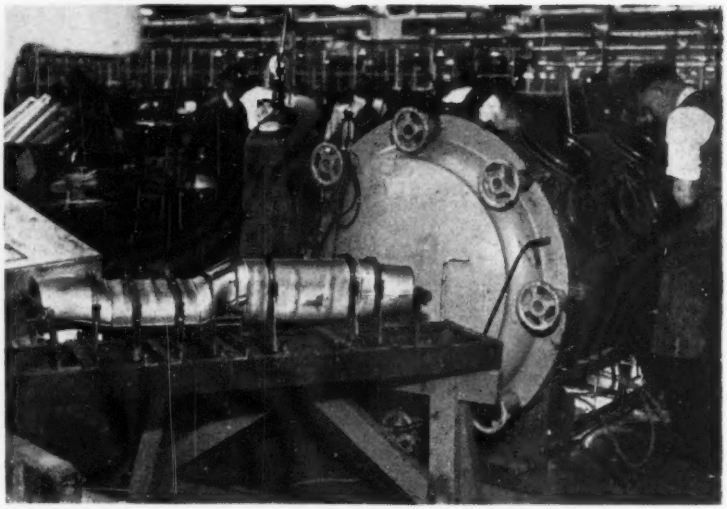


Fig. 5. Argon Chamber for Welding Titanium. A Jig and Workpiece are Seen in the Foreground. (de Havilland Aircraft Co., Ltd.)

The English Electric Co. are carrying out hot-forming operations on titanium alloy. For these operations, a rubber die press is employed, and the rubber bolster of the press is protected by a silicone rubber insulating blanket. Titanium sheets and the steel form blocks are heated to about 300 deg. C. in an electric oven adjacent to the press table, as can be seen in Fig. 4.

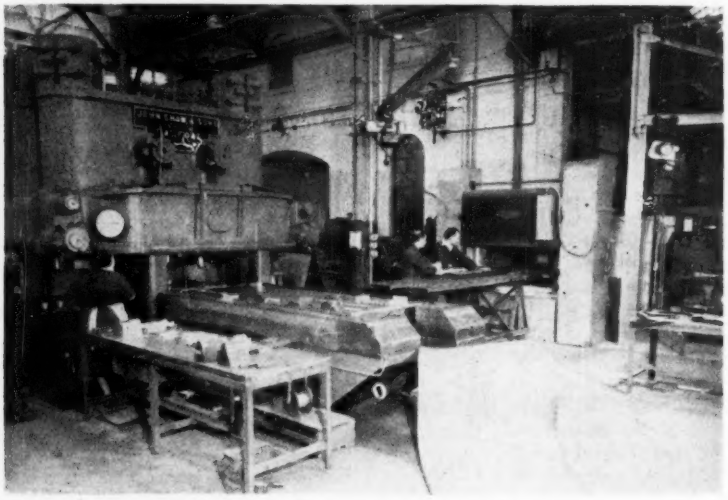


Fig. 4. Arrangement of a Rubber Die Press and Electric Oven for Hot Forming Titanium Sheet. The Rubber Bolster is Protected by a Silicone Rubber Blanket. (English Electric Co., Ltd.)

Titanium can be welded quite satisfactorily in an inert atmosphere, but any trace of nitrogen, oxygen, or hydrogen in the weld zone causes unacceptable embrittlement. Welding is therefore carried out in an argon atmosphere. For this purpose an argon arc torch is employed to protect the weld pool, and the component is mounted on a welding fixture, with a groove at the back of the weld line so that argon can be conveyed to this area, in order to prevent contamination of the heated material. This method of welding is quite suitable for flat sheets and welds. For a complicated component, however, it is difficult to make a jig to provide argon backing at every weld point, and welding chambers are generally used. Vickers-Armstrongs (Aircraft), Ltd. are welding consider-

able quantities of titanium components in such chambers. Fig. 5 shows a welding chamber in use at the works of de Havilland Aircraft Co., Ltd. The jig and work are seen in the foreground. These welding chambers are made in a variety of sizes to suit different components, so that argon, which is an expensive gas, can be used in the most economical manner.

The chambers are weld-fabricated from mild steel plate, and have windows of Perspex or shatter-proof plate glass, through which the work can be viewed by the operators. Manipulation of the welding torch and rods, within the chamber, is carried out by means of rubber gloves through sealed openings at the front. Means are provided for exhausting the chamber by vacuum pump, and charging it with argon after evacuation. The most satisfactory vacuum pump for this work is the rotary oil-immersed type. A high degree of vacuum can be obtained, and a single charge of argon after evacuation ensures the required conditions. The welds produced in these chambers are silvery in appearance and uncontaminated.

Titanium is a metal which is susceptible to work-hardening and fatigue, and where a component has been subjected to heavy forming, or is likely to have high residual thermal stresses as a result of welding, it is subjected to a stress-relief heat treatment. For this purpose, it is held at a temperature of 450 to 500 deg. C. in an electric muffle, for a period which depends upon the gauge of the metal.

A little titanium is machined for airframe parts, and numerous machined items are beginning to appear in jet propulsion units. Experimental machining of this material has not presented the very difficult problems that might have been expected as a result of studying early literature on the subject.

SHEET METAL FORMING

There have been very few real developments in connection with sheet metal forming during the past decade. Such techniques as routing and rubber forming, which revolutionized the manufacture of small light alloy components during the few years immediately preceding the war, have not been paralleled in recent times. Developments of these techniques have resulted, however, from the introduction of the Verson Wheelon press and Hydroform press.

These two presses are now used extensively, and need no introduction. In addition, there have been several minor developments which present points of interest. Folland Aircraft, Ltd., are stretch-forming magnesium on heated form blocks. Fig. 6 shows a typical block and the component produced. Electric heating elements are secured to the under-side of the forming surface of the hollow block. It is the practice of this company to employ 5-kW. per 100 lb. weight of tool, and the magnesium is formed at 280 deg. C. Forming is carried out very gradually, in order that heat can flow from the tool into the workpiece by direct contact. No doubt a similar technique would also be suitable for the forming of titanium-based materials.

Blackburn & General Aircraft, Ltd., and Vickers-Armstrongs (Aircraft), Ltd., both use Hufford A.46 forming machines, fitted with curved jaws. Such jaws greatly facilitate the forming of double curvature panels, and permit considerable savings in material.

A. V. Roe & Co., Ltd., have developed an interesting method of producing socket components, fork ends, and similar forms. Such parts are made by impact extrusion, and the technique is being developed to enable its application to be extended. A much improved grain structure and surface finish are obtained, with consequent improvement in the fatigue life of components, and the amount of machining required is reduced to a minimum. Impact extrusion is a chipless method of producing tubular components by forcing a punch into a billet, located in a die, with sufficient force and velocity to cause the material to flow to

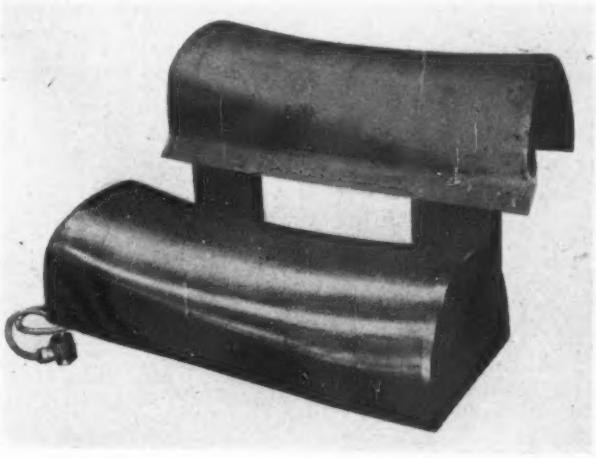


Fig. 6. Forming Block Employed for Hot Stretching Magnesium and a Component. (Folland Aircraft, Ltd.)

N

the desired shape. Fig. 7 shows sections of fork ends which have been produced by this method.

AIRCRAFT ASSEMBLY

Methods of jigging vary from factory to factory, and depend, to a large extent, on the design philosophy of a particular company. The Fairey Aviation Co., Ltd., have developed an assembly method known as envelope tooling. Briefly, with this method, a sub-assembly is built from the outside inwards, instead of building up a structure and then applying a skin. All cumulative tolerances are adjusted on the internal structure, and extremely accurate profiles can be obtained in this way. The company has also designed 3-dimensional lofting equipment to simplify the construction of this type of assembly jig.

Handley Page, Ltd., have adopted spot-welded structures extensively. These structures, it is stated, are cheaper, and have higher surface finishes than those produced by the more normal riveting techniques. It is also claimed that spot welding enables lighter structures to be obtained. Stringers and drawn sections are produced to very close limits to ensure accuracy of the assembly. Welding is also employed in sandwich construction. For this purpose, a corrugated form is spot welded to the outer skin, and the inner skin is blind riveted to the tops of the corrugations. A very stiff, strong structure is thus obtained, which is used for wing planks and fuselage sections.

Fig. 8 shows the continuous seam welding machine which Handley Page, Ltd., employ for welding stringers and structures. A high standard of spot welding is maintained by means of rigid quality control, and primary structures for both the Victor and the Herald aircraft are being welded.

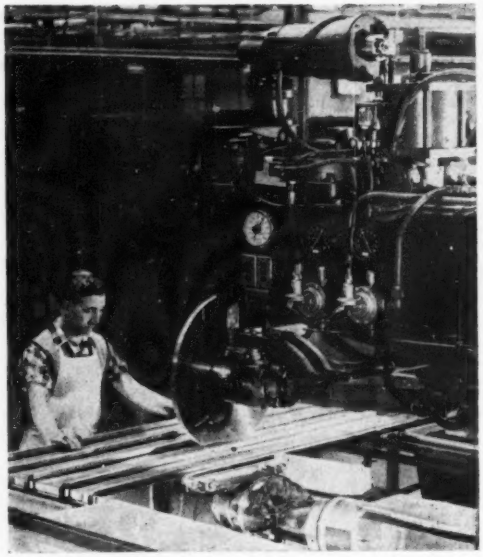


Fig. 8. Continuous Seam Welding Machine Employed for Operations in Stringers and Structures. (Handley Page, Ltd.)

Fig. 9 shows a stainless steel beam made by Bristol Aircraft, Ltd., by puddle welding. The heat source is an arc, struck between a non-consumable tungsten electrode and the work. Both the electrode and the weld area are shielded by an inert atmosphere of argon gas. Sheets to be welded are held in intimate contact, between the shroud of the torch and a grooved backing plate, during welding and solidification. The electrode does not touch the work, and there is no forging action, such as occurs in resistance spot welding.

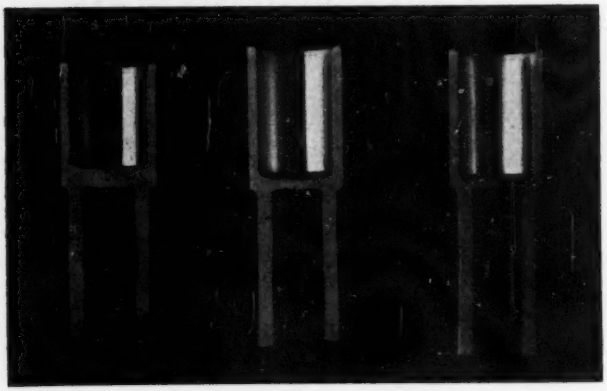


Fig. 7. Sections of Fork Ends Produced by Impact Extrusion. (A. V. Roe & Co., Ltd.)

CHEMICAL PRODUCTION METHODS

Most British aircraft firms are experimenting with, or are producing parts by, chemical contouring. With this technique, a part is protected by a suitable masking medium over certain areas, other portions of the material being left exposed. On

immersion in an etching solution, material is eroded away from the unprotected areas. This process offers considerable advantages for formed components, since they may be etched in the formed state, and the difficulties experienced in forming when the cross-section is not uniform are thus avoided. Etched areas of different depths can be obtained by progressive de-masking. In the U.S.A., a Neoprene base paint is employed for masking, but British practice differs in some instances.

The technique employed at Vickers-Armstrongs (Aircraft), Ltd., is as follows:—The part is first thoroughly cleaned, and, then is sprayed with a plastics film which has little adherence. A light alloy template is laid on the workpiece, and the areas to be etched are cut round with a model knife. Next, the plastics film is stripped from the areas to be protected, while the areas to be etched are left covered. A priming coat, and two coats of an epoxy resin paint, are then applied, and cured by stoving at a comparatively low temperature. When the paint is dry, it is easy to lift a corner of the protective film remaining on an area to be etched, and to strip away the film and paint together, leaving very sharp edges.

The epoxy resin is very adherent to the base metal, whereas the plastics film has little or no adherence, but fairly high tensile strength and flexibility, so that it can be stripped from an area in one piece.

Subsequently, the component is immersed in a 15 per cent solution of caustic soda at 85 deg. C. for a period of time which depends on the depth of etch required. Etching proceeds uniformly over the whole surface at a rate which varies from 0·040 in. to 0·060 in. per hour. When etching has been completed, the part is washed, immersed in a de-oxidizing bath, and washed again. The paint is then removed, and the part is finally inspected and anodized.

Some firms specify heat treatment after etching, in order to minimize the risk of reduced fatigue life as a result of hydrogen embrittlement. Fatigue tests have shown that the scatter, for chemically eroded specimens, is very much less than that for similar items produced by machining. A greater overall accuracy can also be obtained with chemical erosion than by machining.

In producing the templates, some allowance must be made for the fact that etching proceeds sideways as well as downwards. At the edges of a pocket, a radius is formed which is a function of the depth of etching. This radius is an advantage from the standpoint of stress distribution, but somewhat limits the depths to which parts can be etched satisfactorily.

No hand finishing is necessary on chemically contoured specimens. Since the paint is flexible, the part can be formed after it has been masked, and then etched. The etching solution can be reclaimed by a seeding process, and used repeatedly.

Chemical contouring shows significant economies as compared with machining methods, especially as a polishing operation is generally needed to smooth machining marks. The following are representative of the savings that have been achieved by Vickers-Armstrongs (Aircraft), Ltd. Taking machining times as 100 per cent, rudder skins are produced in 19·5 per cent of the time, aileron skins in 25·3 per cent, a fuselage panel in 67 per cent, an access panel in 80 per cent, and a tailplane skin panel in 32 per cent. The larger and more complicated the pocket areas, the greater are the savings.

Experiments are now in progress with the object of applying this process to the contouring of titanium and alloy steels. Such operations have been carried out successfully in production in the United States, to limited depths, but this stage of development has not yet been reached in the United Kingdom.

Vickers-Armstrongs (Aircraft), Ltd., have developed a process which enables used files to be

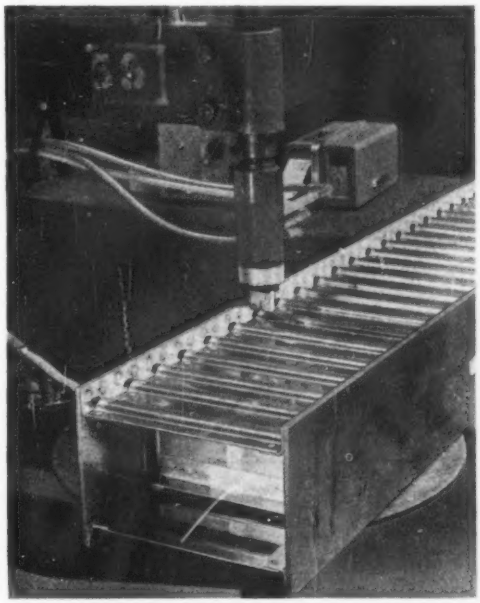


Fig. 9. Stainless Steel Beam Fabricated by Puddle Welding. (Bristol Aircraft, Ltd.)

reclaimed. Referring to Fig. 10, a worn file is immersed in a bath of 56 per cent sulphuric acid, and a voltage is applied between the bath and the file. Electrolytic action then causes preferential erosion of the flanks of the file teeth, so that fresh cutting edges are formed. Heavy milled-tooth files can be reclaimed as many as seven times, and the cost of the process is negligible. The voltage is about 8, and the current load for a 10-in. file is 100 amp. A period of 10 min. is sufficient for the reclamation of the average file. In the tank shown, 12 files can be processed at one time.

The same company is also developing an electrolytic erosion technique for the production of components and templates. A part is drawn out on stable material, and then photographed. A photosensitive mask is applied to the template or work material and developed, using the photo-negative. The sheet is then immersed in an electrolyte, and an electric current reverse-plates those areas which are exposed, etching away the material to produce the required form. At the moment, the process has not reached an advanced stage of development.

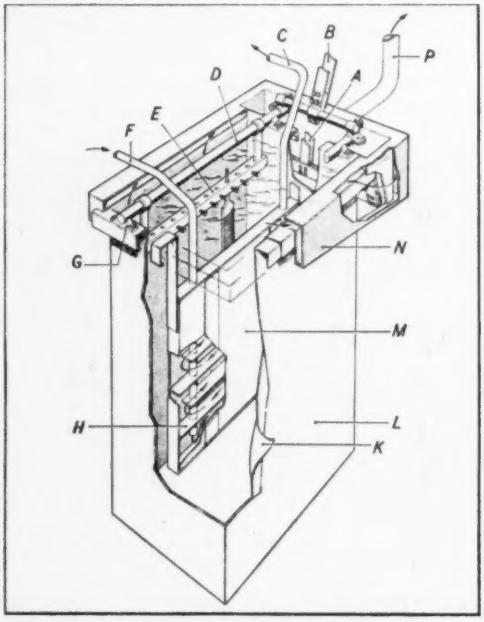


Fig. 10. Vat Employed for Reclaiming Files. A—Negative Bus-bar. B—Positive Bus-bar. C—Cathode Cooling Outlet. D—Brass Anodes. E—Brass File Carrier. F—Cathode Cooling Inlet. G—Insulator. H—Baffle Plates. K—Lead Lining to Vat. L—Mild Steel Vat. M—Stainless Steel Cathode. N—Vent Ducting. P—Vent Outlet. [Vickers-Armstrongs (Aircraft), Ltd.]

With the advent of high-strength materials and increasing quantities of machined items, fatigue becomes an important consideration. Most machine marks can be regarded as potential stress raisers, and certain of them must be removed by some finishing operation. With the high-strength steels, this problem becomes more acute, since the machined finish obtained tends to be progressively worse, and the notch sensitivity greater.

For many years past, the British aircraft industry has used the barrelling technique for the removal of machine marks and stress raisers.

Another effective finishing process is vapour blasting. Some aircraft firms employ shot peening for the elimination of stress raisers. Short Brothers & Harland, Ltd., have done considerable development work on this process, and employ extra-fine shot with a special impelling device to produce a very close surface, stressed in compression.

STAINLESS STEEL HONEYCOMB AND METAL ADHESIVE BONDING

Many aircraft companies are employing metal adhesives in the fabrication of primary structures including Bristol Aircraft, Ltd., de Havilland Aircraft Co., Ltd., A. V. Roe & Co., Ltd., and Vickers-Armstrongs (Aircraft), Ltd. For curing, electrically heated muffles, steam-heated presses, and steam-heated autoclaves are employed. The extent to which honeycomb sandwich construction has been developed in this country is indicated by Fig. 11, which shows a honeycomb sandwich panel made by A. V. Roe & Co., Ltd.

Higher Mach numbers must inevitably result in an increasing use of steel in aircraft and missiles. Stainless steel sandwich construction, with honeycomb core, is recognized as one of the most efficient. The brazing of steel honeycomb is extremely difficult, but A. V. Roe & Co., Ltd., have successfully tackled the problem, and have fabricated some very large structures. Fig. 12 shows a cylinder of 6 ft. 4 in. diameter, which was brazed in one piece. Both the outer and inner facings and the case, are of a stainless steel, designated F.V.520, which was especially developed for the company by Firth-Vickers. It is a chrome-nickel-copper-molybdenum stainless steel of the precipitation hardening type.

Unless precautions are observed, the high temperature necessary causes oxidation of the metal surface, with the result that brazing will not take place. A great deal of development work has been undertaken by A. V. Roe & Co. in order to overcome these difficulties. The components to be

Fig. 11. A Large Redux-bonded Honeycomb Sandwich Panel. (A. V. Roe & Co., Ltd.)

brazed are sealed in "coffins," which are purged thoroughly with nitrogen, and a gaseous flux is then introduced. It is necessary to use a special type of honeycomb in order that each cell may be able to breathe, so that all air can be removed. Brazing is carried out in large, electrically-heated furnaces, and, when the operation has been completed, nitrogen is again introduced to expel the gaseous flux from the "coffins." Other firms experimenting with brazed steel honeycomb structures seal the components in "coffins," which are then evacuated and subsequently filled with argon gas.

PLASTICS

Most of the British aircraft firms are using considerable quantities of plastics materials for tooling purposes, and applications include drop hammer tools, rubber die tools, ironing caps for rubber die tools, hammer form blocks, and dressing blocks. Glass-cloth resin-bonded laminates are employed, for example, for the manufacture of drill gates, profile plates, routing templates, and chemical erosion templates. In addition, resin-bonded tubing of reinforced glass-cloth laminate is used extensively for jigs and checking fixtures. It has been found very satisfactory, because of the ease with which modifications, repairs, and changes can be made. It is light, virtually indestructible, and stable, and will doubtless find increasing application in the future. Glass-cloth laminates are being used for the attachments of aircraft canopies, also laminates of Terylene artificial fibre cloth, which possesses great strength.

Bristol Aircraft, Ltd., have been experimenting with automatic injection methods for the manufacture of fibre-glass resin - bonded mouldings. The methods employed point the way to the automatic and economical production of components in large quantities, while maintaining a high standard of dimensional accuracy, coupled with consistency of moulding.

The company have designed, and are manufacturing in large quantities, asbestos phenolic resin-bonded drop tanks. These tanks, which can be nested for ease of storage and transport, are made by the autoclave method. The pre-impregnated asbestos felt is laid up in aluminium tools, and cured for 20 min., at a temperature of 150 deg. C. and a pressure of 100 lb. per sq. in. Fig. 13

Fig. 12. Large One-piece Cylinder of Brazed Stainless-steel Honeycomb Construction. (A. V. Roe & Co., Ltd.)

shows a pair of moulds being loaded in the autoclave. Each tool has a flexible inner lining, through which pressure can readily be applied to the moulding.

Most of the large companies in Britain now produce canopies, of truly circular cross-section, by vacuum forming techniques. For this purpose, a heated Perspex blank is draped into a forming box, and suction is applied. External air pressure then forms the Perspex into the desired shape. The heated Perspex does not touch any form block, and is only restricted at the edges, where it is to be attached to the metal frame, so that the required peripheral shape is obtained. Canopies produced in this manner have very good optical properties, and much time is saved because less hand polishing is necessary.

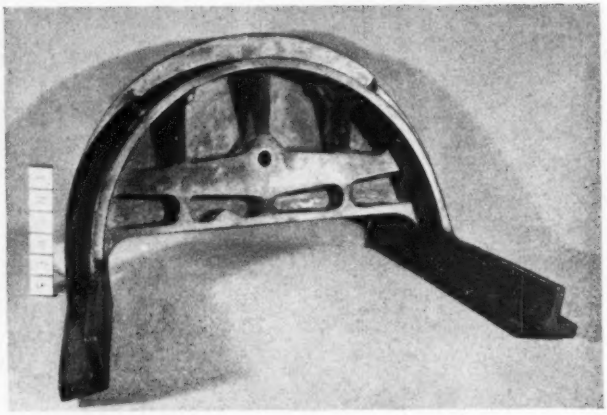


Fig. 14. A Canopy Rear Arch Member Moulded from Fibre Glass Laminate. (English Electric Co., Ltd.)

In Fig. 14 is illustrated a canopy rear arch member for the Canberra Mk. 9 aircraft, moulded from fibre glass laminate. It was originally designed to be machined from a D.T.D. 304 casting, and the estimated machining time was 40 hours. By moulding in glass cloth, a considerable saving in time is achieved. The component is moulded to size from Y.346, twill weave, 0·007-in. laminate, pressure impregnated with Marco resin SB.28C.

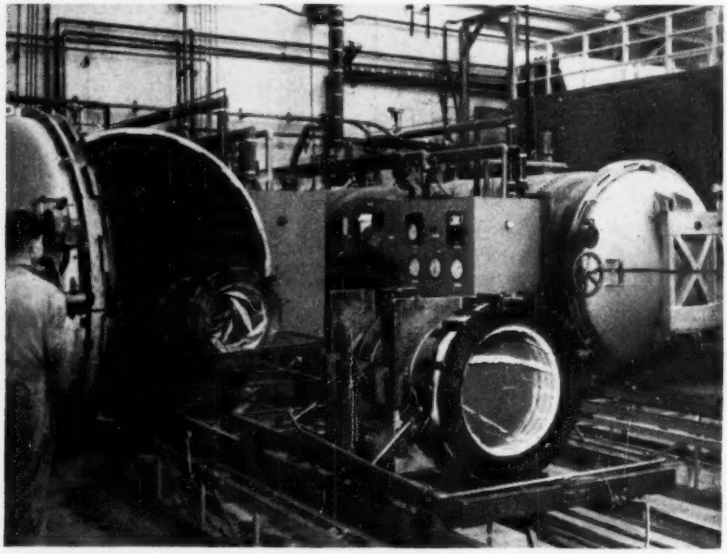


Fig. 13. Moulds for Phenolic Resin-bonded Asbestos Drop Tank Components are Loaded into an Autoclave for Curing. (Bristol Aircraft, Ltd.)

CONCLUSIONS

The British aircraft industry is vitally aware of the need for continued improvement of existing methods and the development of new production techniques. Almost every company has established a production development department, not only to consider and develop new and improved processes, but to ensure the widest possible dissemination of knowledge among those responsible for production. There is ample evidence that the principle of co-operation in this sphere has been, and is being, applied, not merely inter-departmentally, but throughout the companies of the industry as a whole. The author acknowledges, with gratitude, the unstinted assistance given by the companies mentioned in the paper, in the form of information and photographs.

New Bar Rolling Mill at the Works of Sanderson Brothers & Newbould, Ltd.

Brief reference was made in MACHINERY, 92/55—3/1/57, to the official starting-up of a new 10½-in., double-duo, bar rolling mill at the Attercliffe Works of Sanderson Brothers and Newbould, Ltd., Sheffield, on December 20, by the Lord Mayor of Sheffield, Alderman A. Ballard, C.B.E. The mill, a general view of which is given in Fig. 1, has been installed as part of the company's modernization programme, and was built by the Brightside Foundry & Engineering Co., Ltd., Sheffield, to replace two existing mills. It will be employed for a mixed rolling programme of high-speed, tool, and alloy steels, including steels for bright turning.

Bars up to 60 ft. long can be rolled, in sizes from ⅜ to 1⅜ in. diameter, and equivalent sections and flats up to 3 in. wide. The rolling speed is 300 to 900 ft. per min. Two existing buildings were joined to accommodate the mill, and the lay-out has been arranged to permit ready transfer of finished material to the heat-treatment and bright-bar departments.

The double-duo roll arrangement, which is shown in Fig. 2, has been adopted, in preference to a 3-high type mill, to obtain better size control, and to ensure improved flexibility in operation. There are two pairs of rolls *A-B* and *C-D*, so that, in effect, each roll housing contains two 2-high mills running in opposite directions. The bar enters through the rolls *C-D*, and is returned through the rolls *A-B*, which are so arranged that the bar can emerge without any danger of fouling the roll *C*.

Bars can be finished in any one of the last three stands of a train of five, and the floor is arranged accordingly.

The mill is equipped with roller bearings, and will roll to close dimensional tolerances. Drive is transmitted through a reduction gear, with input and output flexible couplings, to a gearbox designed to suit the roll arrangement indicated in Fig. 1, the rolls in the various stands being connected by universal-type mill couplings. Provision is made for the installation of a sixth stand of rolls, if desired.

Made from Hitest cast iron, the roll housings are fitted with cast steel chocks. The top rolls and their chocks are balanced by springs and suspension bolts, and are adjusted vertically by means of forged steel screws, operated by swivel levers and notched discs. A supply of river water, for cooling the rolls, is provided by a Worthington-Simpson Monobloc pump capable of delivering 400 gal. per min. A tank is provided on each housing, and the water level is controlled by ball-operated valves. The water is directed on to the rolls through flexible hose pipes, and the scale is carried through a scale pit into a collecting pit, which can be cleared as required.

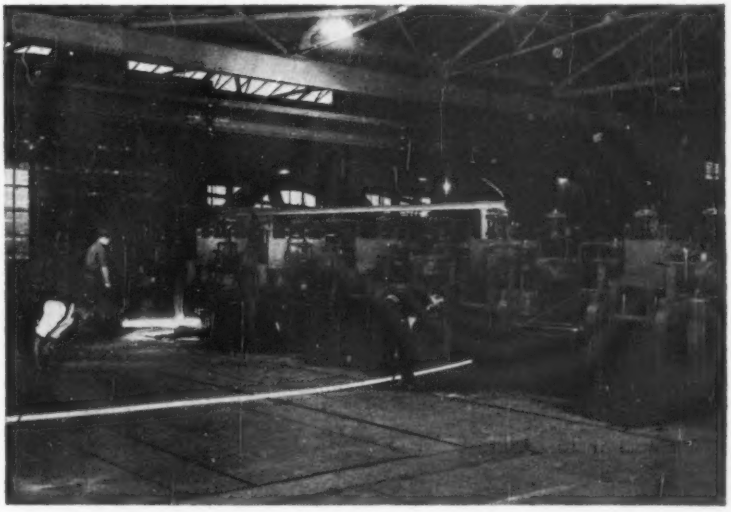


Fig. 1. New 10½-in. Double-duo Bar Rolling Mill Installed in the Attercliffe Works of Sanderson Brothers and Newbould, Ltd., Sheffield

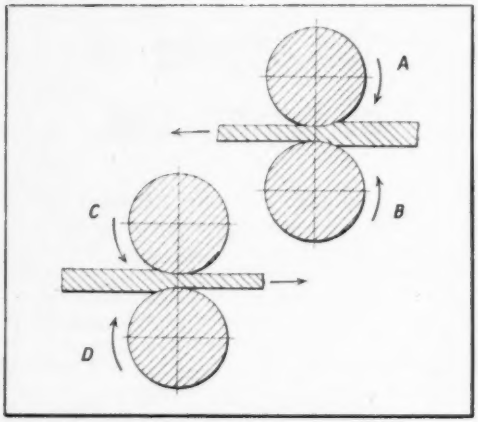


Fig. 2. Double-duo Arrangement of Rolls

To facilitate roll changing, spare housings are provided, to enable two complete stands of rolls to be prepared while the mill is in operation. The housings are transferred to the mill, from the housing assembly bed, by a Shelvoke & Drewry heavy-duty fork-lift truck. Roller bearings are fitted into the rolls by means of oil injection, in a dust-free fitting shop and roll store.

The mill is powered by an English Electric 500-h.p. direct-current motor with a speed range of 300 to 900 r.p.m. After the motor has been started and brought to its minimum speed by the sub-station attendant, speed regulation is taken over by the mill supervisor. A control desk, adjacent to the roughing stand, is equipped with a load-indicating ammeter, speed control regulator and meter, and an emergency stop button. The motor is arranged for dynamic braking.

For the time being, billets are to be heated in a continuous-type, pulverized-fuel-fired furnace, which served the former 10-in. mill. To enable production to be maintained, this mill has been kept in operation during the building of the double-duo mill. In due course, the old mill and its steam engine will be dismantled, and additional billet furnace capacity added.

Live roller gear is provided for the transmission of billets from the furnace to the roughing stand, and hot cogging shears are installed adjacent to the roughing stand for use when required. Live roller gear is also provided to carry the finished material to the hot saw or shears. Power-operated transfer gear on the outgoing side of the mill enables bars to be moved from the last three stands, across the floor, to the live roller gear. This transfer gear consists of seven chain-type skids. A Clifton & Baird hot saw is fitted with a Sanderson 36-in. diameter blade, and the saw pendulum is actuated by a Hele-Shaw self-contained hydraulic system. The hot shear at present in use has been adapted for the purpose, and will subsequently be replaced by a Mubea shear, capable of cutting bars up to 2 in. round or square.

On leaving the hot shear, bars pass on to an outgoing live roller table. Bars and flats which do not require slow cooling or reeling are transferred to a straightening rack, whence they are subsequently removed by overhead crane. Bars for reeling are transferred to a second rack, and thence to a Platt hot reeler. After the reeling operation, they are passed into a loading and storage rack. Bars for which furnace cooling is specified are charged into a town's gas-fired, temperature-controlled, slow cooling furnace, positioned opposite the end of the live roller conveyor leading from the shears. Other material, for retarded cooling, can be passed into a nest of slow cooling tubes surrounded by insulating powder and cased in.

Finished bars are removed by overhead crane to a despatch section at the end of the mill. Bars to be hardened and tempered, normalized, or annealed, are placed on stillages, arranged at the side of a bay in the finishing section, whence they are picked up by a revolving charging machine in the adjacent heat-treatment department and loaded directly into the heat-treatment furnaces.

A newly-installed Carruthers 3-ton overhead electric travelling crane serves the mill floor and finishing section, while the despatch section and an 8-in. mill, which will remain in operation for the time being, are served by an existing overhead crane. Mill lighting is provided by a mixture of tungsten and mercury fluorescent lamps, which provides an average illumination of 20 lumens per sq. ft. Cloakroom accommodation for the workpeople, and a new mill office are to be erected shortly.

Technological Education Conference

A report on the conference on Modern Technological Education for Industry, which was held at Cheltenham in October, has been issued by North Gloucestershire Industrial Education Council, 8 Lansdown Place, Cheltenham, from whom copies may be obtained (price 5s. each). The texts of addresses on "the school education for an engineering career" and "the new diploma in technology" are given, also the ensuing discussions. In addition, the speeches at the conference dinner are reported. The conference was attended by some 250 delegates from many branches of industry, educational establishments and various associations.

New Showrooms for Elgar Machine Tool Co., Ltd.

Elgar Machine Tool Co., Ltd., and their associates, The Press & Shear Machinery Co., Ltd., have recently occupied new showrooms at 172-178 Victoria Road, Acton, London, W.3. The new premises, part of which is shown in the illustration, have a floor area of 40,000 sq. ft., and a 25-ton crane is installed in one of the bays to facilitate handling machines. A gallery extends for the length of the building at one side, and when proposed alterations have been carried out it will provide additional space, amounting to some 5,000 sq. ft., for the display of fairly light machines and equipment. There are well-appointed offices at the gallery level.

To mark the opening of the showrooms, the companies recently held demonstrations of some of the British- and Continental-made machines for which they are the selling agents. More than 200 machines were on view, and among those handled by Elgar Machine Tool Co., Ltd., were noted German-made Boley & Leinen centre, capstan, second operation, turret, and thread-chasing lathes; Traub automatics with capacities for bar stock from $\frac{1}{32}$ to $1\frac{5}{8}$ in. diameter; Webo bench-mounted and pillar drilling machines; a Beichle die miller; a Karstens hydraulic universal grinder with a centre height of 5 in.; a Schneider type JOH3 slideway grinder fitted with two wheelheads; and a Bohner & Koehle type F3 vertical milling machine with a 31- by 51-in. work table. Czechoslovakian - made machines handled by the company were represented by a TOS type R5 2-in. capacity turret lathe, with provision for pre-selecting spindle speeds and feeds; and MAS radial drilling machines and a horizontal-spindle die sinker.

During the demonstration period, Mr. W. Westbrock, managing director of Fritz Hurxthal Maschinenfabrik, Remscheid, Germany, gave an address in which he drew attention to the wide range of horizontal-spindle, plano-, rotary table, and drum type milling machines made by his company, and distributed in this country by Elgar Machine Tool Co., Ltd. He explained that, due to restricted production capacity, his firm had built only special-purpose milling machines since the end of the second world war, many of which had been supplied to leading companies in Europe. The recent provision of improved manufacturing facilities had enabled the firm's range to be extended, and reference was made to new, large-capacity, plano-milling machines which are available with different numbers and arrangements of spindle heads, and to a duplex horizontal milling machine with programme control. Many of the special-purpose machines and some of the new designs were illustrated by means of slides, and a short film was shown, in which a large automatic ingot scalping machine, built by the company, was seen in operation.

The range of sheet metal working equipment shown by The Press & Shear Machinery Co., Ltd., included the recently-introduced Hycoform type

A View of Part of the New Showrooms of Elgar Machine Tool Co., Ltd.

D35H hydraulic spinning and flow turning lathe made by the German firm of Bohner & Kohle, which was described in MACHINERY, 91/1378—13/12/57. Reference may also be made to the German-built Hilu motor-driven friction screw press of open-front design which is available in five sizes with capacities from 6 to 100 tons. Other equipment of German origin which was demonstrated included a Behrens-Wemag 18-ton turret punching machine, and various sizes of Elmeg electro-magnetic press units. These latter machines have adjustment for stroke and daylight, and the force of blow can be steplessly varied. Dial feeds are available, and the power heads can be supplied separately, if required. The new, British-made, lever-operated angle bending machine, which was on view, is available in six sizes with capacities for forming metal sheets up to 20, 26 and 30 in. wide by 20 s.w.g., and up to 36, 42 and 48 in. wide by 18 s.w.g.

Letters to the Editor

[The Editor does not hold himself responsible for the views expressed by his correspondents.]

Keeping Productive Machines in Operation

[To the Editor of MACHINERY]

SIR,—The interesting editorial in MACHINERY, 91/1359—13/12/57 entitled "Increasing Machine Productivity" formed an appropriate sequel to that under the heading "The Application of Automatics to Small-batch Production" which appeared in the previous week. Both articles will, no doubt, give your readers much food for thought.

The sequence-controlled automatic capstan lathes which I have been using for nearly four years are not particularly expensive to install, but even so it is desirable that they should be kept running as many hours a week as possible because they are obviously more productive than other machines which require individual operators. Apart, perhaps, from jig borers and very accurate grinders, almost any wholly manually-operated machine may therefore often be economically shut down for an extra hour each day, so that its operator not only has his own mid-day meal, but can then tend three or four automatic or semi-automatic machines while their regular operator has his break.

Any question of shift working requires a certain amount of tact in negotiation, but this staggering of breaks and meal times is essential where the introduction of special equipment to provide largely automatic machine cycles has rendered some of the plant more productive than the remainder. A good centre-lathe turner will always be worth his weight in gold, but he must be intelligent enough to realize that for batch work an increasing measure of automation will be needed to subsidize him if his firm is not to price itself out of the market. Skilled men who refuse to take any interest in automatic machines, or even prefer that they should be closed down during breaks, are like ostriches with their heads in the sand. If such a man spends the evening in his home workshop, he not only turns something on a lathe while the shaper is working, but has tea and studies the drawings as well.

IAN NICKOLS,
Nickols Automatics, Ltd.

London.

Buck & Hickman Exhibition

New machine tool offices and showroom have recently been completed at the works of Buck & Hickman, Ltd., Otterspool Way, Watford By-Pass, Watford, Herts., and the showroom will be opened on January 20. For a period of two weeks from that date an exhibition of more than 60 machine tools will be staged, many of which will be in operation, and all engineers interested are invited to attend.

Among the machines to be demonstrated we may note the following: a British-built Bryant type 1109 precision internal grinder; a Holbrook type D.15 mould-maker's lathe, arranged for profile turning; a British-built Brown & Sharpe No. OOG automatic screw machine; a Victoria Rapidmill milling machine; a Victoria Victomatic 0-18-in. production milling machine; a B.N.L. hydraulic vertical surface grinder; a Pacera multi-spindle tapping machine; and a Pacera deep-hole drilling machine with incremental feed.

Nickel Supplies

Dr. John F. Thompson, chairman of the board of the International Nickel Company of Canada, Ltd., reports that: "After many years of nickel shortage for civilian purposes, the combined supply of market and premium price nickel came into close balance with demand in nearly all areas of the world during the last part of 1957. In fact, in the largest market, the United States, the supply exceeded the demand." . . . "This change was brought about by a record free world production of nickel, sharply reduced defence demands, and the U.S. Government's endeavour to divert to industry during the year all nickel scheduled for stock-pile intake."

Whereas free world defence requirements were substantially lower than in 1956, civilian consumption increased to the extent of approximately compensating for the reduced defence consumption. Free world nickel supplies in 1957 are estimated to have totalled 490,000,000 lb., compared with the previous record figure of approximately 450,000,000 lb. in 1956. Deliveries of the metal by the various Canadian producers reached a figure of about 360,000,000 lb., of which International Nickel contributed more than 290,000,000 lb.

News of the Industry

Manchester and District

FAIR DEMAND FOR FOUNDRY IRON.—A moderate amount of new business in common foundry iron is being placed by users in this area, and they are calling for a fair aggregate tonnage against existing contracts. Stocks at the Midland blast-furnaces are still fairly high so that quick deliveries are obtainable. Although consumption locally is slightly greater than it has been of late, it is still below the normal level. The demand for haematite iron from the engineering foundries and other users remains reasonably steady. Derbyshire No. 3 iron is quoted at £21 1s. 3d. per ton for delivery in the Lancashire zone, and Staffordshire low-phosphorus foundry iron at £24 1s. 3d. and West Coast haematite at £25 5s., both delivered in the Manchester area.

STEADY CALL FOR STEEL MATERIALS.—Both finished and semi-finished steel materials are being called for against existing contracts at a moderate rate, and new business is coming to hand at a fairly steady level. Light, medium and heavy plates, as well as sheets, are in request, and for heavy joists and sections, medium and large round bars, and special alloy steels in round and hexagon forms, there is a regular demand. Among semi-finished products, forging blooms and billets are required in substantial quantities. There is also a fair movement of crown bars and other finished-iron materials.

METROPOLITAN-VICKERS ELECTRICAL CO., LTD., Trafford Park, Manchester, have recently received orders for transformers and switchgear, to the value of £500,000, from the Electricity Trust of South Australia.

GRESHAM & CRAVEN, LTD., Salford, as a result of growing export business and orders for vacuum brake cylinders for British Railways modernization plans, are finding it necessary to extend their new works at Worsley. Brake cylinders are on order for British Railways diesel trains.

SKIL ENGINEERS, LTD., Chell Street, Longsight, Manchester, have recently developed the Skilform compound radius forming tool for general workshop use. Simple in design, the tool can be applied for dressing grinding wheels to arcs and angles for form grinding, and for radius grinding tool-bits and form tools. It can also be used as a compound table with screw adjustment for both slides, and as an indexing fixture for milling, drilling and grinding. Convex or concave surfaces can be formed up to 1½ in. radius, and the work table measures 5½ by 3 in. We hope to describe the equipment more fully in due course.

MATTERSON, LTD., Shawclough, Rochdale, are experiencing a brisk demand for all their products. A new drawing office has recently been occupied, and good progress is being made with the works extensions which will double the machine and erecting shop floor space. The request for No. 11 and No. 12 thread milling machines, which are marketed by Dowding & Doll, Ltd., 346 Kensington High Street, London, W.14, is maintained at a good level, and there is a steady call for spur and bevel gear generating attachments for use on shaping machines. Standard 2- 3- and 6-speed gearboxes find a ready sale, and we may also note orders for special types. There is much activity in the hoist and crane department, where new designs of 1- and 3-ton hoist units and a 10-ton crab will shortly be introduced.

ORMEROD ENGINEERS, LTD., Shawclough, Rochdale, are steadily employed on a variety of repetition machining work, which includes turning, thread milling, splining and hobbing. Other orders in hand cover aircraft loading winches for the R.A.F., Shirley metering pumps for the textile, chemical and food manufacturing industries, emulsifiers, and sub-contract portable swing-frame grinders for the Universal Grinding Wheel Co., Ltd., Stafford. Our attention was drawn to a recently-completed differential gearbox, incorporating pick-off gears, which provides a very limited range of speed variation in both the forward and reverse directions and transmits up to 5 h.p. We hope to make further reference to this unit at a later date.

FROST (ROCHDALE), LTD., Crawford Street, Rochdale, report a steady home and export demand for sheet metal working machinery of various types. Guillotine shearing machines on order range from treadle types up to the 8-ft. by ¼-in. size, folding machines, up to 8-ft. by ¼-in., and bending rolls, up to 6-ft. by ⅜-in. A worm-driven shearing machine was recently ordered by the South African Railways for dealing with 8-ft. by ⅜-in. sheets, and a motor-driven 6-ft. by ⅜-in. machine is on order for cutting plastics sheets.

BUTTERWORTH BRITISH AUTOMATIC MACHINE

TOOL CO., LTD., Lincoln Street, Rochdale, are fully occupied with the production of their hydraulic-type bar automatics, which are being built in sizes for machining bars up to 1⅝, 2 and 2½ in. diameter.

THOMAS ROBINSON & SON, LTD., Railway Works, Rochdale, report a steadily maintained demand, on both home and export account, for their various types of woodworking machinery, as well as for flour milling machinery and equipment. India and Canada are good export markets. On the woodworking machinery side we may note the development of a range of simpler and smaller machines particularly intended for users operating on a small scale. An order for machinery for equipping a new flour mill has recently been received from Karachi, Pakistan.

JOHN HOLROYD & CO., LTD., Milnrow, Rochdale, are experiencing a steady demand for all types of gear-cutting and for gear reduction units. Arrangements have recently been made whereby the De Laval Steam Turbine Co., of New Jersey, U.S.A., will manufacture Holroyd worm gear drives in that country, using Holroyd technique and plant. In the machine tool department orders are in hand for a variety of equipment. H. B.

Obituary

MR. FRANK G. WOOLLARD, M.B.E., died recently at the age of 74. Born in London and educated at the City of London School, he served his apprenticeship under Mr. Dugald Drummond, M.Inst.C.E., chief mechanical engineer of the then L.S.W.R. He gained his early automobile experience on the motor buses of the L.S.W.R. and then with Weigel Motors, Ltd. In addition, he spent some time with Medhurst & Brewer, consulting engineers. Mr. Woollard joined the firm of E. G. Wrigley & Co. as chief draughtsman in 1910, became director and chief engineer in 1917, and assistant managing director in 1918. During the first world war he was responsible for a large output of tank gearboxes and was hon. consultant for gearing to the Tank Department. He joined Morris Engines (Coventry), Ltd., as general manager in 1923, at the time when the business was taken over from Hotchkiss et Cie. Subsequent production developments, for which he was largely responsible, were described at length in MACHINERY during 1925, as many readers will recall. In particular the semi-automatic continuous machines which were introduced for operations on cylinder blocks, flywheels, and gearboxes, afforded evidence of remarkable foresight, and were the forerunners of the modern line transfer machines that began to appear some 20 years later.

Mr. Woollard was appointed managing director of Rudge Whitworth, Ltd., in 1932, and four years later was made a director of the Birmingham Aluminium Casting (1903) Co., Ltd., and the Midland Motor Cylinder Co., Ltd. When the Zinc Alloy Die Casters Association was formed in 1952 he represented the Birmingham Aluminium Casting Co. on the Council. In 1951 he became chairman and continued to hold this office until the beginning of 1956. During his chairmanship the Association introduced the Certification Mark Scheme for zinc die castings, organized a productivity team which visited the U.S.A., and selected members to participate in the O.E.E.C. mission in 1954. Mr. Woollard presided over the first International Die Casting Conference which was another important event of 1954.

He took an active part in the affairs of the Institution of Automobile Engineers and held the office of president for two years starting in 1945. During this period he was closely concerned with the negotiations that led to amalgamation with the Institution of Mechanical Engineers.

Mr. Woollard retained the keenest interest in all the aspects and implications of what has now come to be known as automation, and was the author of a book entitled "Principles of Mass and Flow Production" which was published in 1954.

MR. ALASTAIR MCLEOD, head of the metallurgical editorial staff of Industrial Newspapers Ltd., died in London on January 3 at the age of 58. An expert on rolling mill practice, he received his metallurgical training in Scotland and was for many years with Frederick Braby & Co., Ltd., Glasgow, and other Scottish rollers of sheet steel, before he came to London to take up the editorship of *Sheet Metal Industries*. At the time of his death he was managing editor of *Sheet Metal Industries*, *Metal Finishing Journal* and *Metal Treatment and Drop Forging*, also chief metallurgical editor of the *Iron and Coal Trades Review*.

MR. McLeod was a Fellow of the Institution of Metallurgists and an hon. vice-president of the Institute of Sheet Metal Engineering, which he was largely instrumental in founding. He was also a member of several other organisations including the Iron and Steel Institute, the Institute of Metals, the Institute of Welding, the Institute of British Foundrymen, and the Institution of Production Engineers.

MR. H. MATTHEWS, joint managing director, of Crofts (Engineers), Ltd., Thornbury, Bradford, died suddenly on December 28.

The Steel Supply Position

(*Continued from page* 59)

be necessary to seek increased business overseas, and expansion of exports may become more difficult if there is any further fall in commodity prices. It is also possible that, in the changed circumstances, certain obsolescent plant may be scrapped earlier than had been intended, with some gain in average efficiency.

The long-term implications of the prevailing situation will no doubt be carefully examined, but so far, it is suggested, there is nothing to justify any change in the steel industry's development proposals which have already been announced. In this connection it may be noted that world production of crude steel has risen from 153·4 million tons in 1948 to an estimated 291 million tons in 1957, and so far there has been no indication of any general slackening in the upward trend.

New Year Honours

Mr. Stanley J. Harley, B.Sc., M.I.Mech.E., M.I.Prod.E., chairman and managing director of the Coventry Gauge & Tool Co., Ltd., was made a Knight Bachelor in the New Year Honours.

Born at Coventry in 1905, Mr. Harley studied at Bablake School, Coventry, Wrekin College, Wellington, and Birmingham University, and completed his technical education on the Continent and in the U.S.A. He joined the Coventry Gauge & Tool Co., Ltd., in 1926, and in 1935 was appointed joint managing director with his father, the late Sir Harry Harley. He became deputy chairman and managing director in 1946, and was appointed chairman after the death of his father in 1951.

From 1940 to 1946 he served in an honorary capacity as Controller of Jigs, Tools and Gauges, Machine Tool Control, Ministry of Supply.

Mr. Harley is also chairman of Coventry Gauge & Tool Co. (Aust.) Pty., Ltd., Coventry Gauge & Tool Co. (Canada), Ltd., Pitter Gauge & Tool Co., Ltd., British Engineers Small Tools & Equipment Co., Ltd., and Bestec (Canada), Ltd., and a director of Coventry Precision, Ltd., Cardinal Steels, Ltd., Gillott Forge & Rolling Mills, Ltd., and Variform, Ltd.

Apart from his business interests, Mr. Harley has played an active part in the affairs of various associations and institutions. He is a member of the Council of the Machine Tool Trades Association and holds the office of chairman of the Standards Policy Committee.

In addition, he has been a member of the Council of the Gauge and Tool Makers' Association for 10 years and was elected deputy president in 1955. He has also been a Council member of the National Federation of Engineers' Tool Manufacturers since 1946, and a vice-president since 1950.

Always keenly interested in standardization, he has been chairman of numerous committees of the British Standards Institution, and is a past-chairman of the Engineering Divisional Council. In this field he has represented the United Kingdom as a leader or member of delegations concerned with international and Commonwealth standards, and he has been a leading participant for many years in the work of unification of engineering standards between America, Canada, and this country. Mr. Harley served on the Council of the Institution of Mechanical Engineers from 1954 to 1956, and is a member of the Council of the Institution of Production Engineers and a past-president of the Coventry Branch.

A Knighthood was also conferred on Dr. Ashley S. Ward, president of Thos. W. Ward, Ltd., Albion Works, Sheffield. Dr. Ward, a nephew of Thomas W. Ward, the founder, joined the company as a young man. He afterwards went to London to promote the firm's interests in the south, and subsequently established the extensive Silvertown Works. He became, in succession, assistant managing director and joint managing director, and in 1941 was appointed chairman and managing director on the death of Dr. Joseph Ward, J.P., a younger brother of the founder. He continued in this office until 1950, when he was appointed the first president of the company, a post which he still holds.

In 1939, Dr. Ward became the firm's third Master Cutler, and he was invited to continue in office during the war years but was obliged to decline on account of business commitments. He has done much work for education, and in 1955 Sheffield University conferred on him the degree of Doctor of Law.

In addition to his presidency of Thos. W. Ward, Ltd., Dr. Ward is chairman of the Park Gate Iron & Steel Co., Ltd., and vice-chairman of Laycock Engineering Co., Ltd.

Mr. S. J. Harley

Dr. A. S. Ward

The names of some other recipients of New Year Honours are listed below:

Knights Bachelor

Barnard, A. T., Director-General of Inspection, Ministry of Supply.

Cook, W. R. J., Deputy Director, Atomic Weapons Research Establishment, Aldermaston, U.K. Atomic Energy Authority.

Worboys, W. J., chairman, Council of Industrial Design; director, Imperial Chemical Industries, Ltd.; vice-president, Associated British Chemical Manufacturers.

C.H.

Nuffield, William Richard, Viscount.

K.C.B.

Melville, H. W., secretary, Department of Scientific and Industrial Research.

C.B.

Constant, H., director, National Gas Turbine Establishment, Ministry of Supply.

Serby, J. E., Director-General, Guided Weapons, Ministry of Supply.

G.B.E.

Yarrow, Sir Harold Edgar, Bt., chairman and managing director, Yarrow & Co., Ltd., Glasgow.

K.B.E.

Gass, N. A., chairman, British Petroleum Co., Ltd.

C.B.E.

Ball, E. H., managing director, British Thomson-Houston Co., Ltd.

Crook, A. E., principal inspector, mechanical engineering, Mines Inspectorate.

Mason, J. A., manager and director, Automatic Telephone & Electrical Co., Ltd.

Metcalfe, C., managing director, E.M.I. Electronics, Ltd.

West, R. W., Principal, Battersea College of Technology.

O.B.E.

Appleton, L. R. E., chief engineer (weapons division), Fairey Aviation Co., Ltd., Hayes, Middlesex.

Dorey, V. E., principal examiner, Patent Office, Board of Trade.

Elford, Lt.-Col. E. N., manager, radar division, Marconi's Wireless Telegraph Co., Ltd., Chelmsford.

Hammond, R. A. F., principal scientific officer, Armament Research and Development Establishment, Ministry of Supply.

Hancock, E. W., director of Humber, Ltd., past president of the Institution of Production Engineers, and chairman of Coventry Local Productivity Association.

Hunwicks, S. A., senior principal scientific officer, Royal Aircraft Establishment, Ministry of Supply.

McMahon, R. A., secretary, British Electrical and Allied Industries Research Association.

Rowe, E. G., chief valve engineer, Standard Telephones & Cables, Ltd., Sidcup.

Seligman, H., deputy chief scientist, head of Isotope Division, Harwell, U.K. Atomic Energy Authority.

Swift, W., director and deputy general manager, Joseph Lucas Gas Turbine Equipment, Ltd., Birmingham.

Sykes, A., technical director, David Brown & Sons (Huddersfield), Ltd.

Coming Events

INSTITUTION OF ENGINEERING INSPECTION.—*Birmingham Branch.* January 15, at 7.30 p.m., at the Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham; paper on "Non-destructive Testing by Ultrasonic Methods," by J. W. Fox. *South Western Branch.* January 14, at 7.30 p.m., at the Grand Hotel, Broad Street, Bristol; paper on "Modern Trends in Non-destructive Testing," by R. S. Sharpe, B.Sc.

INSTITUTION OF MECHANICAL ENGINEERS.—*Eastern Branch.* January 14, at 7.30 p.m., at the Great White Horse Hotel, Ipswich; paper on "The American System of Education and Training of Mechanical Engineers," by H. S. Arms, D.Phil., M.A. *East Midlands Graduates' Section.* January 21, at 7.15 p.m., at the College of Technology and Commerce, Room 104, Leicester; paper on "Air Aids to Production," by N. J. Beaumont. *Industrial Administration and Engineering Production Group.* January 16, at 6.45 p.m., at the Institution of Mechanical Engineers, 1 Birdcage Walk, London, S.W.1; discussion on "Export Packing of Engineering Products."

INSTITUTION OF PRODUCTION ENGINEERS.—*Doncaster Section.* January 14, at 7.15 p.m., at the Danum Hotel, Doncaster; lecture on "Air in the Service of Man," by a representative of Holman Bros. Ltd. *Halifax and Huddersfield Graduate Section.* January 20, at 7.30 p.m., at the Percival Whitley College of Further Education, Halifax; lecture on "Precision Finishing Machines and Operations," by E. D. Haigh. *Birmingham Section.* January 15, at 7 p.m., at the James Watt Memorial Institute, Great Charles Street, Birmingham; lecture on "Inter-Process Mechanisms for Press Work," by J. P. Udal. *Birmingham Graduate Section.* January 14, at 7 p.m., at the James Watt Memorial Institute, Great Charles Street, Birmingham; lecture on "Component Production from Metal Powder," by G. R. Bell, B.Sc. *Coventry Section.* January 20, at 7.15 p.m., at the Craven Arms, High Street, Coventry; lecture, illustrated by a film, on "Impact Extrusion and Cold Flow Pressing of Ferrous and Non-ferrous Metals," by H. Byles. *Newcastle-upon-Tyne Section.* January 20, at 7 p.m., at the Neville Hall, Newcastle-upon-Tyne; lecture on "Spark Machining," by E. A. Sweetman. *Peterborough Section.* January 14, at 7.30 p.m., at the White Lion Hotel, Church Street, Peterborough; lecture on "Cost Reduction by Production Planning and Control," by R. J. Smithson. *Southampton Section.* January 16, at 7.15 p.m., at the Polygon Hotel, Southampton; lecture on "Automobile Accessory Production," by Mr. Lusted. *Cornwall Section.* January 16, at 7.15 p.m., at the Camborne School of Mines, Camborne, Cornwall; lecture, illustrated by film, on "The Role of the Metallurgist in Production Engineering," by H. Bartle. *Swansea Section.* January 17, at 7.30 p.m., at the Central Library, Alexandra Road, Swansea; lecture on "Mechanical Aids to Inspection," by L. Hare.

Personal

DR. W. D. SCOTT, F.R.I.C., B.Sc., A.R.C.S., has been appointed assistant managing director of B.T.R. Industries, Ltd., Herga House, Vincent Square, London, S.W.1.

MR. J. SMART has been appointed a director of Vaughan Associates, Ltd., 4 Queen Street, Curzon Street, London, W.1. He will continue to hold the position of general manager of the company.

MR. A. J. BURTON has joined the board of The Austin Motor Co., Ltd., Longbridge, Birmingham, following his services as a local director. As works director, Mr. Burton is responsible for production at the Longbridge Works, also at the following B.M.C. factories: Tractors and Transmission Branch, Morris Commercial Cars, Ltd., Morris Motors Engines Branch, and Nuffield Tools & Gauges, Ltd.

MR. T. A. E. LAYBORN, C.B.E., has also joined the board.

Mr. A. J. Burton

MR. HAROLD FRITH, who has been manager of the Leeds sales office of Brook Motors, Ltd., since 1920, retired at the end of 1957. Starting as an apprentice 50 years ago, he served for some time as assistant with the Brook Canadian subsidiary, the Langdon-Davies Motor Co. (Canada), Ltd., Toronto, and later took up the appointment in Leeds. A silver cigarette box was presented to Mr. Frith by the directors. MR. R. SPENCE, A.M.I.E.E., who joined the company in 1937, has taken over the management of the Leeds sales office.

Scrap Metals

†LONDON.—‡Prices per ton for non-ferrous scrap metals free from iron are as follows:—clean copper wire, untinned and free from lead and solder, £145; clean heavy copper, untinned and free from lead and solder, £137; second grade copper wire, £132; clean light copper £129; braziery copper, £115; gunmetal, £125; brass mixed, £83; lead, net, £59; zinc, £30; cast aluminium, £88; old rolled aluminium, £121; battery lead, £31; unsweated brass radiators, £68; hollow pewter, £495; black pewter, £365.

MIDLANDS.—The New Year has opened none too brightly for the ferrous scrap trade. Many users of scrap in all areas still have suspensions in operation and the allocations so far made are very meagre.

Heavy steel material is being forwarded to markets outside the Midlands, with the result that "free-on-rail" prices are much lower than those which could be offered when scrap was sold locally. No. 4 bundles are in demand instead of the higher priced 0.04 S. & P. bundles, and merchants are reducing their prices for light steel pressing scrap.

Prices for turnings have been cut as most loads from the Midlands can only be forwarded to blast furnaces in the Sheffield and Derbyshire areas. Outlets for busy turnings are very scarce, and merchants are anxiously waiting for markets to re-open. In the meantime large tonnages are being held in stock.

Short heavy steel scrap is taken in this district under allocation, but more markets are needed to cover all the material forthcoming from merchants' yards. It is particularly difficult to find outlets where delivery can be accepted by rail.

Cast iron scrap is moving steadily, but foundries are working below maximum capacity and will not buy solely for stocking.

Unless the tonnages of scrap in merchants' yards are cleared very soon, it will be necessary to restrict inward traffic to an economic level.

In general, although maximum selling prices are still controlled, buying prices are likely to ease.

Current maximum control prices, delivered consumers' works, are now: *Heavy steel No. 1, 217s. 6d.; *heavy steel No. 2, 196s.; *heavy steel No. 4, 207s. 6d.; *heavy steel No. 5, 195s. 6d.; light iron No. 8, 149s.; short turnings No. 9 (free from alloy), 167s. 3d.; light steel No. 11, 164s. 3d.; bushy turnings, 117s.; short alloy turnings, 160s. 9d.; short steel No. 2, 233s. 3d.; machinery cast, 233s.

Prices may be increased up to 2s. 6d. per ton according to quantities tendered over a given period.

* For use by Round Oak Steelworks, Brierley Hill, increase by 1s. 6d. per ton.
† George Cohen, Sons & Co., Ltd., Commercial Road, E.14.
‡ Subject to market fluctuations.

The Price of a Subscription to MACHINERY is 52 Shillings per annum, post free, to any part of the world.

Subscribers are not bound for any definite period of subscription. We send MACHINERY, post free, each week until told to stop. Subscribers can pay yearly, half-yearly, or quarterly, pro rata. (Cash with order)

To MACHINERY, National House, 21 West Street, Brighton 1.

Please send me/us MACHINERY every week until I/we tell you to stop, for which I/we enclose remittance of 52 Shillings per annum or pro rata

Name .....

Address .....

.....

**Position* .....

**Firm* .....

* For our mailing records only.

10/1/58

Trade Publications

JOHNSON, MATTHEY & CO., LTD., 73-83 Hatton Garden, London, E.C.1. Leaflet describing a new Mallory electrode holder adapter of improved design. It is of 3-piece construction and incorporates two clamping caps which can be set at various angles to the shank.

SCHOFIELD & SAMSON, LTD., Roger Street, London, W.C.1. Catalogue of 122 pages, with stiff covers, devoted to gears, racks, gear units and screws. Much useful technical information is included, and for each type of gearing the company's capacity is clearly indicated. Sections are devoted, for example, to spur and bevel gears, hardening, worm gearing, helical and spiral gearing, thread milled screws, and worm reduction units.

WILD-BARFIELD ELECTRIC FURNACES, LTD., Elecfurn Works, Otterspool Way, Watford By-Pass, Watford, Herts. Leaflet giving a general description and abridged specification of the type 2904 laboratory vacuum furnace for operation at temperatures up to 2,000 deg. C. It has melting capacities of 2 lb. of steel (tilting) and 8 lb. (non-tilting).

Machine Tool Share Market

The tendency of stock markets was mainly firm during the past week. Prices advanced steadily in most sections, and there was some expansion in the volume of business.

Activity was greatest in the gilt-edged section, where British Funds and kindred stocks showed to advantage, and closed on a good note, with a general rise on the week.

In the principal sections of the industrial share market a satisfactory undertone prevailed. Although interest remained moderate, and price movements showed some irregularity, changes on balance were mainly to slightly higher levels.

Among machine tool issues, Broom & Wade rose 1s. 6d. to 11s. 6d.; Chas. Churchill, 1½d. to 4s. 9d.; Coventry Machine Tool, 3d. to 8s. 6d.; John Shaw & Sons (Wolverhampton), 6d. to 12s. 4½d.; and Sheffield Twist Drill, 1s. 3d. to 35s. On the other hand, Asquith Machine Tool lost 3d. at 18s. 6d.; Churchill Machine Tool, 3d. at 17s. 4½d.; John Holroyd "A," 3d. at 11s.; John Holroyd "B," 3d. at 10s.; Wadkin, Ltd., 3d. at 20s.; British Oxygen, 7½d. at 31s. 10½d.; Jones & Shipman, 1s. 3d. at 22s. 6d.; and Samuel Osborn, 6d. at 74s. 6d.

COVENTRY GAUGE & TOOL CO., LTD.—Final dividend 4¾ per cent (tax free) making, with the interim, a total distribution of 6¼ per cent (tax free) (same).

COMPANY		Denom.	Middle Price
Abwood Machine Tools, Ltd.	Ord.	1/-	1/-xd
Armstrong, Stevens & Son, Ltd.	Ord.	5/-	17/-
Allen (Edgar) & Co., Ltd.	Ord.	£1	30/-
" " "	5% Prf.	£1	15/-*
Arnott & Harrison, Ltd.	Ord.	4/-	14/-
Asquith Machine Tool Corp., Ltd.	Ord.	5/-	18/6
" " "	6% Cum. Prf.	£1	17/9
Birmingham Small Arms Co., Ltd.	Ord.	£1	27/-
" " "	5% Cum. "A" Prf.	£1	15/-
" " "	6% Cum. "B" Prf.	£1	17/6
" " "	4% 1st Mort. Deb.	Stk.	84½
British Oxygen Co., Ltd.	Ord.	£1	31/10½
" " "	6½% Cum. Prf.	£1	20/6
Brooke Tool Manufacturing Co., Ltd.	Ord.	5/-	5/6
Broom & Wade, Ltd.	Ord.	5/-	11/6
" " "	6% Cum. Prf.	£1	16/10½
Brown (David) Corporation, Ltd.	5½% Cum. Prf.	£1	12/6
Buck & Hickman, Ltd.	6% Cum. Prf.	£1	18/9
Butler Machine Tool Co., Ltd.	Ord.	5/-	9/3xd
" " "	5% Cum. Prf.	£1	15/9
C.V.A. Jigs, Moulds & Tools, Ltd.	5½% Red. Cum. Prf.	£1	13/9
Churchill (Charles) & Co., Ltd.	Ord.	2/-	4/9
" " "	6% Cum. Prf.	£1	26/3†
Churchill Machine Tool Co., Ltd.	Ord.	5/-	17/4½
" " "	6% Cum. Prf.	£1	18/9
Clarkson (Engrs.), Ltd.	Ord.	5/-	10/6
Cohen (George), Son & Co., Ltd.	Ord.	5/-	10/6
" " "	4½% Cum. Prf.	£1	14/3
Coventry Gauge & Tool Co., Ltd.	Ord.	10/-	15/-xd
" " "	5% Cum. Red. Prf.	£1	17/6
Coventry Machine Tool Works, Ltd.	Ord.	4/-	8/6
Craven Bros. (Manchester), Ltd.	Ord.	5/-	6/10½
Elliott (B.) & Co., Ltd.	Ord.	1/-	3/-
" "	4½% Red. Cum. Prf.	£1	13/9
Export Tool & Case Hardening Co., Ltd.	Ord.	2/-	1/9
Firth Brown Tools, Ltd.	4% Cum. Prf.	£1	12/-
Greenwood & Batley, Ltd.	Ord.	£1	46/10½
Harper (John) & Co., Ltd.	Ord.	5/-	14/6
" " "	4½% Red. Cum. Prf.	£1	12/9
Herbert (Alfred), Ltd.	Ord.	£1	57/6
Holroyd (John) & Co., Ltd.	"A" Ord.	5/-	11/-
" " "	"B" Ord.	5/-	10/-
Jones (A. A.) & Shipman, Ltd.	Ord.	5/-	22/6
" " "	7% Cum. Prf.	5/-	5/-
Kayser, Ellison & Co., Ltd.	Ord.	£1	55/6
" " "	6% Cum. Prf.	£1	18/3
Kendall & Gent, Ltd.	Ord.	5/-	8/-
Kerry's (Gt. Britain), Ltd.	Ord.	5/-	6/-
Kitchen & Wade, Ltd.	Ord.	4/-	11/-
Martin Bros. (Machinery), Ltd.	Ord.	2/-	2/4½
Massey, B. & S., Ltd.	Ord.	5/-	7/9xd
Modern Engineering Machine Tools, Ltd.	Ord.	5/-	11/-
Newall Engineering Co., Ltd.	Ord.	2/-	5/-
Newman Industries, Ltd.	Ord.	2/-	2/9
" "	6% Prf. Ord.	5/-	5/6xd
Noble & Lund, Ltd.	Ord.	2/-	4/9
Osborn (Samuel) & Co., Ltd.	Ord.	10/-	74/6
" " "	5½% Cum. Prf.	£1	24/6
Pratt (F.) & Co., Ltd.	Ord.	5/-	20/-
Scottish MachineTool Corporation, Ltd.	Ord.	4/-	4/9
Shardlow (Ambrose) & Co., Ltd.	Ord.	£1	35/-
Shaw (John) & Sons, Wolverhampton, Ltd.	Ord.	5/-	12/4½
Sheffield Twist Drill & Steel Co., Ltd	Ord.	4/-	35/-
" " " "	5% Cum. Prf.	£1	15/-
Stedall & Co., Ltd.	Ord.	5/-	5/3
Tap & Die Corporation, Ltd.	Ord.	5/-	8/-
" " "	4½% Deb. 1961-1977	Stk.	91
Wadkin, Ltd.	Ord.	10/-	20/-
Ward (Thos. W.), Ltd.	Ord.	£1	70/7½
" "	5% Cum. 1st Prf.	£1	15/-
" "	5% Cum. 2nd Prf.	£1	23/3
Willson Lathes, Ltd.	Ord.	1/-	2/4½

The Middle Prices given in the list are in several cases nominal prices only and not actual dealing prices. Every effort is made to ensure accuracy, but no liability can be accepted for any error. * Sheffield price. † Birmingham price.